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MANUAL FOR PERFORMANCE ASSESSMENT OF HIGHWAY ASSETS DURING OPERATIONS AND MAINTENANCE STAGE

INDIAN ROADS CONGRESS
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MANUAL FOR PERFORMANCE ASSESSMENT OF HIGHWAY ASSETS DURING OPERATIONS AND MAINTENANCE STAGE

1 INTRODUCTION

Necessity for formulation of a new Manual for Performance Assessment of Highway Assets during O&M Stage was discussed during the first meeting of Project Preparation, Contract Management, Quality Assurance and Public Private Partnership Committee (G-1) held on 26th May, 2018. Accordingly, the new Manual was prepared by Sub-Committee consisting of Shri L.P. Padhy, Shri V.L. Patankar, Shri A.K. Shrivastava, Col. A.K. Bhasin and Dr. Harikishan K. Reddy (Co-Opted). The Sub Committee received contributions from Shri Bhanoj Dokku, Shri Dhiraj Prakash Sethi, Shri Arpan Ghosh and Shri T Ramachandra Reddy while preparing this Manual which is duly acknowledged. The draft was deliberated in a series of meetings. The G-1 Committee finally approved the draft document in its meeting held on 23rd November, 2019 and decided to submit the final draft to IRC for placing before the GSS Committee.

The Composition of G-1 Committee is as given below:

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Padhy, L.P. ..... Co-Convenor
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(Nirmal, S.K.)

The General Specifications & Standards Committee approved the draft document in its meeting held on 6th December, 2019 for placing it before the Executive Committee and IRC Council. The Executive Committee in its meeting held on 19th December, 2019 approved the draft document for placing it before the IRC Council. The IRC Council in its 219th Meeting held on 19th December, 2019 during the 80th Annual Session held at Patna (Bihar) approved the document "Manual for Performance Assessment of Highway Assets during O&M Stage" for printing. IRC acknowledges with thanks ASTM whose Standards have been referred in the manual for better understanding of the concepts.

SECTION 1

GENERAL

1.1 Introduction

A fully constructed highway contains many assets, like, pavement, structures, road furniture (like, roads signage, pavement markings, kilometer stones, etc.), project facilities (like, bus bays, truck lay byes, toll plazas, etc.), Toll Management System (TMS), Highway Traffic Management System (HTMS)/Automatic Traffic Management System (ATMS), etc. Currently there is no comprehensive method to assess the combined performance level of all these highway assets put together. In the absence of a comprehensive asset performance metric, it is often seen that many of the road assets are poorly maintained, resulting in i) discomfort to road users, ii) unsafe travel conditions, and iii) enhanced maintenance requirements and budgets.

Therefore, there is a need to consider a comprehensive method for performance assessment of highway assets at O&M stage.

1.2 Objective

The objective of this manual is to provide a systematic procedure for performance assessment of highway assets, which when employed multiple times for the same highway section at the same time yields consistent performance results. For this purpose, this manual provides a comprehensive rating system – namely, Asset Maintenance and Operations Rating (AMOR). By regular monitoring of AMOR, it is expected that:

i) All highway assets receive required attention for maintenance and operations,

ii) Consequently, will lead to proactive maintenance and O&M cost optimization.

1.3 Scope

Scope of this manual covers' performance assessment of highway assets for the condition as well as operational efficiency.

In this manual, assessment of individual highway parameters based on critical attributes has been included for the purpose of arriving at the overall Asset Maintenance Rating (AMR) as well as Asset Operations Rating (AOR) for entire highway asset. It may be noted that the overall assessment of AMR and AOR is arrived at based on appropriate weightage of individual parameters for estimation purpose. AMR and AOR only indicates the overall condition rating of highway asset and in no way lessen the importance of critical individual parameters contributing safe and reliable functioning of highway. Rating of individual highway parameters shall be analyzed in detail for taking up appropriate rectification/remedial measures for enhancing performance factors to achieve safe and reliable functioning of highway. For this purpose, the Concessionaire/Contractors/Independent Consultant/Authority concerned should prioritize the requirement of rectification/remedial measures of various highway parameters based on applicable contractual and codal provisions.

1.4 Assets to be considered for Performance Assessment of Maintenance

All highways assets shall be considered for performance assessment. For assessment, these assets are classified under six categories as shown in below **Table 1**.

Table 1 Categories and Weightage

Category	Weightage, in % If total Structure Length including culverts is:		
	Less than 20% of Highway length	Between 20 to 50% of Highway Length	More than 50% of Highway Length
Roadway	30	25	25
Road Furniture	20	20	15
Structures	20	25	35
TMS and HTMS/ATMS	15	15	15
Project Facilities	5	5	5
Miscellaneous (toll plaza administrative building, landscaping, eco-friendly measures, etc.)	10	10	5

Note: Wherever a highway stretch comprises of Tunnel (s), appropriate weightage as part of Structures category may be included for the purpose of evaluation. The performance assessment of tunnel (s) may be done by using following manual:

Specifications for the National Tunnel Inventory; Publication No. FHWA-HIF-15-006, July-2015, U.S. Department of Transportation, Federal Highway Administration. URL: https://www.fhwa.dot.gov/bridge/inspection/tunnel/snti/hif15006.pdf

A detailed list of assets, under the above categories, to be considered for performance assessment are:

1.4.1 *Roadway*

i) Pavement
ii) Embankment
iii) Shoulder
iv) Kerb
v) Median
vi) Drainage

1.4.2 *Road Signage and Road Furniture*

i) Pavement Marking
ii) Sign Board
iii) Traffic Blinker/Signal
iv) Highway Lighting
v) Safety Barriers – Rigid/Semi-rigid, etc.

vi) Guardrail
vii) Antiglazer
viii) Footpath
ix) Separator
x) Noise Barriers
xi) Object Marker

1.4.3 *Structures*

i) Wearing coat/Expansion Joints
ii) Deck slab
iii) Beams/Girder of Superstructure
iv) Bearings
v) Substructure-Piers
vi) Substructure-Abutments
vii) Foundations
viii) Protection works
ix) Retaining walls/Reinforced Earth Structures
x) Safety Items
xi) Waterway/Culvert Vents

1.4.4 *Toll Management System (TMS), Highway Traffic Management System (HTMS)/ Advanced Traffic Management System (ATMS)*

1.4.4.1 *Toll Management System (TMS)*

i) Traffic Lights
ii) Automatic Boom Barrier
iii) Operator Monitor
iv) Receipt printer
v) User Fare Display (UFD)
vi) Overhead Lane Status Light (OHLS)
vii) Operator Customized Keyboard
viii) License Plate Indicatory Camera (LPIC)
ix) Document Scan Camera
x) Incident Camera
xi) Automatic Vehicle Classification and Counting system (AVCC)
xii) Weigh in Motion (WIM)
xiii) Static Weigh Bridge (SWB)

1.4.4.2 *Highway Traffic Management System (HTMS)/Advanced Traffic Management System (ATMS)*

i) Video Surveillance System [Pan Tilt Zoom- Photoshop Layered Texture (PLT) Cameras]
ii) Mobile Radio Communication System

iii) Video Incident Detection System (VIDS)
iv) Vehicle Actuated Speed Display System
v) Emergency Roadside Telephone System
vi) Variable Message Sign (VMS) System
vii) Meteorological Data System (MET)
viii) Automatic Traffic Counter-cum-Classifier
ix) Travel Time Estimation System

1.4.5 *Project Facilities*

i) Bus Bay
ii) Truck Lay Bye
iii) Toilet Block/Rest Area

1.4.6 *Miscellaneous*

i) O&M Centre
ii) Material Testing Laboratory
iii) Toll Plaza/Administrative Building
iv) Landscaping
v) Eco-friendly Measures

1.5 Parameters to be considered for Performance Assessment of Operations

Similar to the performance assessment of maintenance, performance assessment shall also be done to assess the efficiency of operations. Performance assessment of operations are broadly divided in to six categories and the same along with corresponding weightages have been shown in below **Table 2**.

Table 2 Operations Categories and Weightages

Category	Weightage, in %
O&M Management Plans & Systems	5
Toll Plaza Operations	30
Emergency Response System	20
Work Zone Safety	15
Encroachments	10
Overall Cleanliness	20

A detailed list of assets, under the above categories, to be considered for performance assessment are:

1.5.1 *O&M Management Plans & Systems*

i) Commitment from Operating Agency
ii) Internal Management Plan (IMP) and SOP's
iii) Outcome Reports

1.5.2 *Toll Plaza Operations*

i) Efficiency in Tolling Operations
ii) Efficiency of ETC
iii) User Comfort

1.5.3 *Emergency Response System*

i) Response Time of Emergency Services
ii) Inventory Availability of Services
iii) Documentation and Training of Staff

1.5.4 *Work Zone Safety*

i) Documentation of safety arrangements at work zones
ii) Review of Safety arrangement during random visit

1.5.5 *Encroachments*

i) Documentation of action against encroachments
ii) Validation of documented encroachment during surprise site visit

1.5.6 *Overall Cleanliness*

i) Usage of Mechanical Equipment
ii) Project Cleanliness
iii) Innovative Technologies

1.6 Methodology for Asset Maintenance and Operations Rating (AMOR)

Highway section to be assessed shall be rated separately for maintenance and operations. This will help in understanding performance of maintenance and operations individually.

Rating method shall be as given below:

- Each parameter of the highway asset shall be measured through a scientific measurement technique, described later in this manual.
- Each asset shall be rated on a scale of 0 to 10 – 10 being best and 0 being worst.
- Combined rating of the highway section (Asset Maintenance Rating (AMR) for maintenance and Asset Operations Rating (AOR) for operations) shall be computed through a weighted average using weightages given in **Table 1** and **2** respectively.

1.6.1 *Combined Rating of Highway Section for Maintenance*

$$AMR = \sum_{i=1}^{N} AR_i \times W_i$$

Where,

AR_i is maintenance rating (0 to 10) for Asset Category i
W_i is weightage for maintenance rating of Asset Category i

1.6.2 *Combined Rating of Highway Section for Operations*

$$AOR = \sum_{i=1}^{N} AO_i \times W_i$$

Where,

AO_i is operations rating (0 to 10) for Asset Category i

W_i is weightage for operations rating of Asset Category i

1.6.3 *Illustrative Example for computation of combined AMR and AOR*

In case, if any parameter/sub-parameter is not part of the highway asset under evaluation, then AMR and AOR shall be estimated excluding the missing parameters without changing the weightages of other parameters/sub-parameters. The evaluated rating shall be extrapolated to the scale of 100, as illustrated under through an example –

In case, if ATMS is not present along the highway asset under consideration, then the evaluation shall be carried out as under:

- Weightage for TMS and ATMS/HTMS parameter is 15 as per **Table 1**.
- Within this parameter, ATMS/HTMS sub-parameter has weightage of 50%, i.e., overall weightage of 7.5 for computation of combined AMR.
- Hence, AMR shall be rated for a Maximum Applicable Score of 92.5 by excluding weightage of ATMS/HTMS component.
- Such estimated AMR at Maximum Applicable Score of 92.5 shall be presented on the scale of 100 using following relation.

$$\text{AMR for Highway Asset} = \frac{\text{Evaluated AMR at Maximum Applicable Score}}{\text{Maximum Applicable Score}} \times 100$$

Similarly, in case river guide banks are not present along the highway under consideration where total structure length including culverts is less than 20% of Highway length and no grade separators are present, then the evaluation shall be carried out as under:

- Weightage for structures is 20 as per **Table 1** within this major/minor bridges have weightage of 80% (20×0.8=16) and similarly within major/minor bridges, weightage for protection works is 10% (16×0.1=1.6) as per **Table 24** to calculate rating for structures.
- Within protection works, river guide banks have weightage of 20%, i.e., overall weightage of 0.32 (1.6×0.2) for computation of combined AMR.
- Hence, AMR shall be rated for a Maximum Applicable Scorve of 99.68 (100-0.32) by excluding weightage of river guide banks.
- Such estimated AMR at Maximum Applicable Score of 99.68 shall be presented on the scale of 100 using above mentioned relation

Similar, methodology shall be followed while estimation of AMR and AOR in case of any one or more missing parameters/sub-parameter along the highway asset under consideration. For avoidance of doubt, missing parameters/sub-parameter means the works that are not provided along the highway asset under the existing contracts but included in one or more categories for overall evaluation of asset.

SECTION 2

ASSET RATING OF ROADWAY – MAINTENANCE

2.1 Introduction

Roadway of a highway section includes different components like Pavement, Embankment, Shoulder, Median, Drain and Kerb. Hence, to evaluate the Roadway, it is necessary to evaluate the individual components and its parameters separately.

2.2 Pavement

To evaluate the condition of pavement, there are many factors that must be considered like different distresses. However, the pavement condition can be understood by evaluating the following parameters as a measure of the condition of the pavement which generally reflect the pavement distresses.

i) Roughness
ii) Structural Strength of the Pavement
iii) Pavement Condition Index (PCI)
iv) Skid Resistance

2.2.1 *Roughness*

Pavement roughness is generally defined as an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle (and thus the user). Roughness is also referred to as "smoothness" although both terms refer to the same pavement qualities.

There are many roughness measuring indexes followed across the world. Bump Integrator (BI) index is followed in India in understanding the riding quality of the road. However, the most accepted index across the world is International Roughness Index (IRI) as it eliminates the effect of vehicle suspension.

2.2.1.1 Measurement Method

To measure roughness of the pavement there are different methods like Fifth wheel Bump Integrator, Roughometer, Laser Profilometer and 3D imaging system. However, considering the accuracy levels and amount of points that can be captured in longitudinal profile; laser Profilometer and 3D imaging system are proposed to measure roughness of the asset. However, if any better method than aforesaid ones are developed in future; the same can be used to measure/estimate the roughness of the pavement.

Laser Profilometer and 3D imaging system are explained briefly in the succeeding paragraphs.

i) Laser Profilometer (Fig. 1)

- Digital Laser Profilometer (DLP) consists of eleven lasers capable of measuring Roughness, Rutting and Macro-texture of the Pavement.
- DLP calculates the longitudinal profile of the road which is then passed through

the Quarter Car Model to calculate the International Roughness Index (IRI) as per the widely accepted methodology (Such as World Bank Guidelines for conducting and calibrating road roughness measurements or equivalent Guidelines).

- The longitudinal profile of road is measured in terms of International Roughness Index (IRI) with an accuracy of +/- 0.5 mm; with the help of lasers and accelerometers situated in each wheel path.
- Roughness can be measured at low as well as at high speeds (100 km/h).
- Profile sampling rate is user definable (typically 25 mm).
- On-board real-time data processing confirms data integrity and data is linked to both chainage and GPS coordinates.

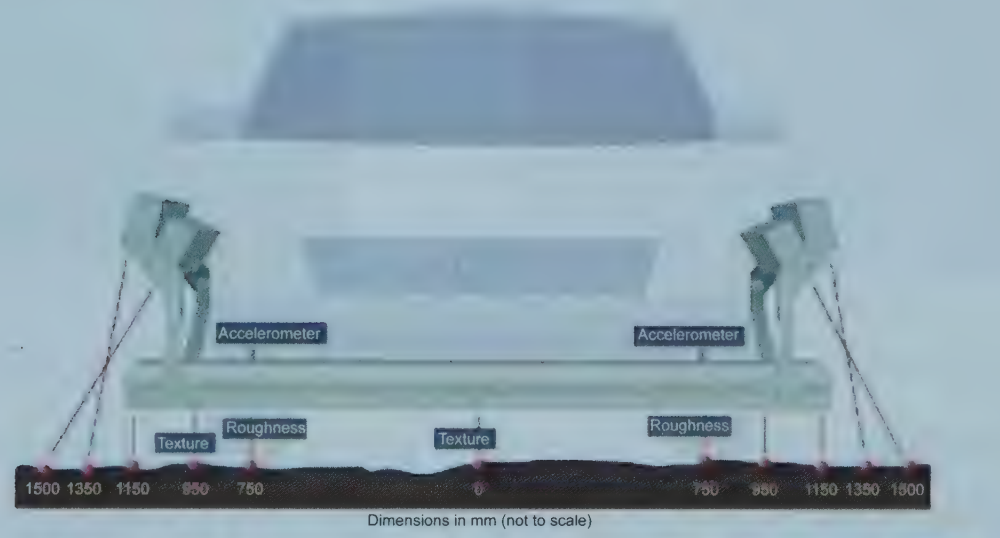


Fig. 1 Laser Profilometer

ii) **3D Imaging System (Fig. 2)**

- Laser Crack Measurement System (LCMS) is the ultimate single-pass 3D sensor for pavement inspection. The LCMS can automatically measure, detect and quantify all key functional parameters of pavement in a single pass, including cracking, rutting, texture, potholes, shoving, ravelling and roughness.
- It can collect and report longitudinal profile and International Roughness Index (IRI) with the precision and bias of an ASTM E950 Class 1 profiler across the entire 3.5 m lane width (data point at every 1 mm).
- It can be operated at very high speeds (100+ km/h) without any effect on accuracy.

- IRI is measured with a vertical resolution of 0.012 - 0.042 mm for 1-inch IRI measurements (confidence level of 95%).

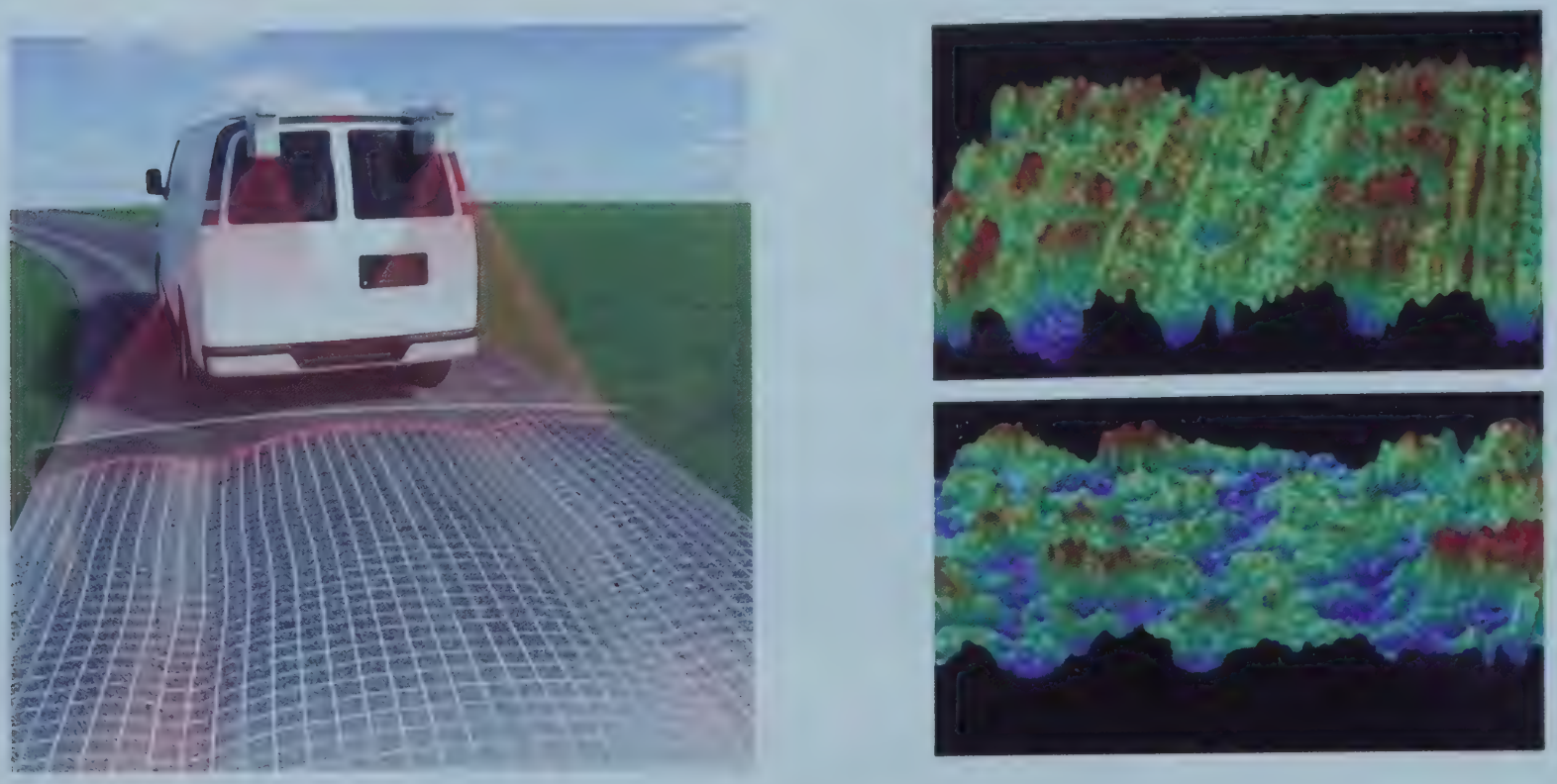


Fig. 2 3D imaging system

2.2.1.2 Rating System

By following the above methods, roughness of the road can be estimated. Now to assess the asset, we need to have the stipulated limits set forth for each asset. The limits can be considered based on the limits specified in the Concession Agreement or the prevailing IRC codes.

In India, generally, most of the concession agreements has a stipulated limit of 3000 mm/km (BI) and corresponds to an IRI of 4.03 m/km (refer IRC:SP:16-2019). As per International standards **(Fig. 3)**, this corresponds to a highway which has been designed for 90 km/h. However, with increasing design speeds of the highway, there is a need to adjust the higher limit of roughness for the new projects.

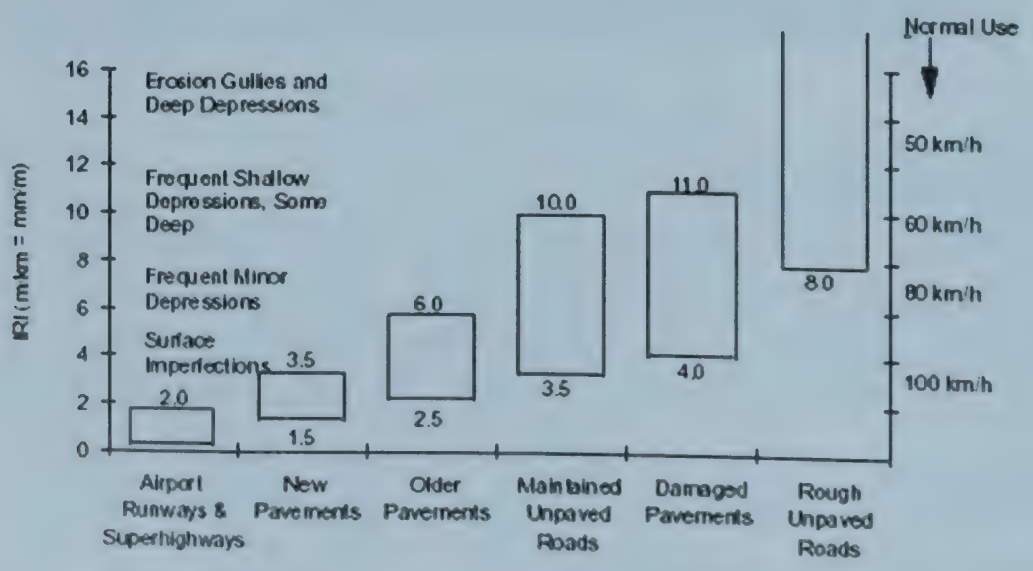


Fig. 3 IRI Requirement based on the Type of Pavement and Corresponding Design Speed

It is a well-known fact that with time, roughness of the asset deteriorates. Hence, while rating it is appropriate to include the influence of time.

Rate of deterioration every year: Assuming the rate of deterioration will be linear, and the trigger limit of the roughness and the corresponding age of the pavement are also.

$$Rate\ of\ detrioration = \frac{(Trigger\ limit - Base\ limit)}{Age\ of\ the\ pavement\ when\ it\ reaches\ trigger\ limit}$$

$$Expected\ roughness = Base\ roughness + Rate\ of\ detrioration \times age\ of\ pavement$$

Age of the pavement is the age at the time of assessment from the time of construction

Equation of the rating curve is as follows,

$$Rating\ points = 10 \times [1 - \frac{\left(e^{(measured\ roughness - expected\ roughness)} - 1\right)}{(e^{(Trigger\ limit - expected\ roughness)} - 1)}]$$

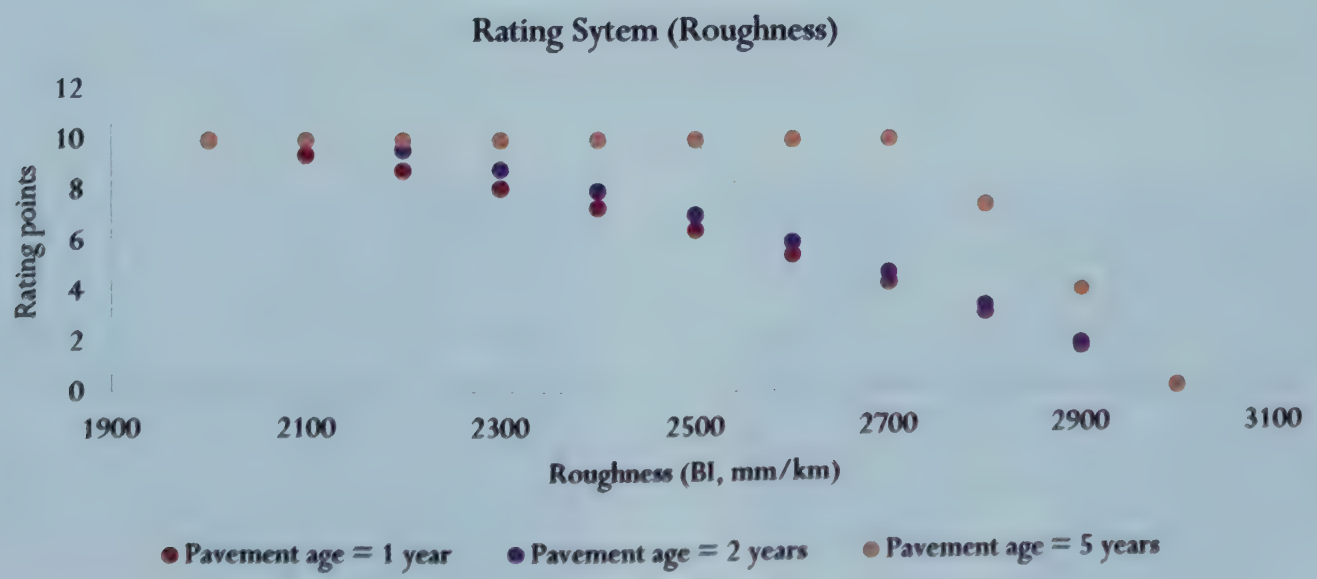
The above equation is valid, when the measured roughness is more than the expected roughness. If the measured roughness is less than the expected roughness the rating points awarded is 10 and if the measured roughness is more than the trigger limit, points awarded are zero. It should be noted that roughness used in the above equation is IRI.

Based on the above, rating points related to roughness of any highway section could be estimated.

Consider a newly constructed road having a roughness 2000 mm/km (=Base limit) and a two-year-old pavement (it has been constructed two years back) has a roughness of 2300 mm/km. During this estimation, it is assumed that the trigger limit of roughness to be 3000 mm/km and assumed it reaches in seventh year after construction. Hence, per year deterioration would be 143 mm/km.

To have a better understanding, the rating system for roughness is shown at different age of the pavement.

Hence, accordingly there will be many curves to estimate the rating points of the asset.



2.2.2 *Structural Strength*

Roughness is used to understand the functional condition of the pavement. Similarly, to understand structural condition of the pavement, it is necessary to determine the existing strength

of the pavement. To understand the strength of the pavement, pavement surface deflection is an important pavement evaluation method because the magnitude and the shape of pavement deflection is a function of traffic, temperature effect on pavement and moisture effect on unbound layers. Hence, deflection could be used to evaluate the existing strength of the pavement as it is used to estimate the moduli of different pavement layers.

2.2.2.1 Measurement Method

There are different methods to evaluate the pavement surface deflection. Out of these, two popular and most used methods in India are Benkelman Beam Deflection (BBD) and Falling Weight Deflectometer (FWD). Between the two methods, FWD is superior to BBD as it can simulate actual traffic loading and allows to back-calculate moduli of existing layers in flexible pavements and identify voids and Load Transfer Efficiency (LTE) in rigid pavements. Hence, FWD is proposed to be used as a method to determine the structural strength of the pavement (however, if any better technology develops in future the same could also be used). FWD is briefly explained in the below paragraph

Falling Weight Deflectometer (FWD) (Fig. 4)

- Falling Weight Deflectometer (FWD) is used to measure the vertical deflection response of a surface to an impulse load.
- A set of weights is dropped onto a platform with springs (rubber buffers) and the impact load is transferred to the pavement through a loading plate.
- Normally the load used on pavements is 40-150 KN depending on the pavements operating in the roads/airports.
- When subjected to the traffic load, the pavement will bend, and a deflection bowl is created. The FWD simulates the wheel load and creates a deflection bowl.
- The sensors record the deflections at various distances from the Centre of loading and a load cell located above the foot system records the loading.

As discussed above, FWD facilitates in finding out the surface deflections and the same could be used to back calculate the moduli of the existing pavement layers (procedure given in IRC:115-2014/IRC:117-2015). Using the back calculated moduli, remaining life of the pavement could be estimated.

Fig. 4 Falling Weight Deflectometer (FWD)

2.2.2.2 Determination of Remaining Life

2.2.2.2.1 Flexible Pavements (IRC:115-2014)

- The following inputs are needed to estimate remaining life
  - o Deflections measured from FWD.
  - o Pavement layer thickness (determined as per procedure stipulated in IRC:115-2014).
  - o Subgrade CBR shall be determined to identify the subgrade modulus range; if in case Dynamic Cone Penetrometer (DCP) is not done to determine modulus.
  - o Results of pavement condition survey (to determine the modulus range of bituminous layers).
- Using the above inputs in KGPBACK (or any equivalent software); modulus of the prevailing layers could be back calculated.
- The back calculated modulus shall be used in IITPAVE (or any such relevant software) to estimate strains at critical locations as defined in IRC:37-2018.
- Based on the strains obtained, remaining life could be estimated by the equations (for both cracking and rutting) given in IRC:115-2014.

2.2.2.2.2 Rigid Pavements (IRC:117-2015)

- FWD should be done at 0 mm, 300 mm, 600 mm and 900 mm from the center of loading plate and the corresponding deflections shall be determined.
- The deflections measured at above radial distances are used to determine the area parameter of the deflection bowl using the equation provided in IRC:117-2015.
- Area parameter is used to determine the radius of relative stiffness (l) from the curves provided/referenced in IRC:117-2015.
- Using the radius of relative stiffness (l) and normalized deflections calculated using various curves provided in IRC:117-2015; modulus of subgrade reaction (k_i) could be estimated.
- Elastic modulus of concrete shall be estimated based on modulus of subgrade reaction (k_i) and radius of relative stiffness (l). Equation to estimate elastic modulus of concrete is also provided in IRC:117-2015.
- Strength of concrete as well as flexural strength of concrete can be estimated using elastic modulus of concrete; these three parameters shall be used to determine fatigue behavior of concrete pavement by following the equations provided in IRC:58 **(Clause 5.8.6)**.

Similarly, voids beneath the concrete slabs can also be found out using the deflection data of FWD. In addition to that, efficiency of load transfer near joints can also be determined using the deflection data of FWD.

2.2.2.3 Rating System

Assessment of roadways asset in terms of structural strength of pavement can be conducted based on the remaining life of the pavement. Generally, pavement design of flexible pavement

of any National Highway is done for a design life of 15 years. Hence, based on the existing remaining life of the pavement and the age of the pavement, rating points are awarded. The rating system for flexible pavement is provided in the below **Table 3**. Similarly, rigid pavements are designed for 30 years and hence based on the remaining life, rating points could be awarded as per below **Table 4**.

Table 3 Rating points based on Structural Strength of the Flexible Pavement

Remaining life of the Pavement → / Time after completion (Age)	1-3	3-6	6-10	>10
1-3	2	4	7	10
3-6	4	7	9	10
6-10	7	9	10	10
>10	10	10	10	10

Table 4 Rating points based on Structural Strength of the Rigid Pavement

Remaining life of the Pavement → / Time after completion (Age)	1-7	7-14	14-20	>20
1-7	2	4	7	10
7-14	4	7	9	10
14-20	7	9	10	10
>20	10	10	10	10

2.2.3 *Pavement Condition Index (PCI)*

The PCI is a numerical indicator that rates the surface condition of the pavement. The PCI provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement, which also indicates the structural integrity and surface operational condition (localized roughness and safety).

The PCI cannot measure structural capacity, nor does it provide direct measurement of skid resistance or roughness. It provides an objective and rational basis for determining maintenance and repair needs and priorities. Continuous monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. The PCI provides feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures.

2.2.3.1 Measuring Method

PCI is estimated based on the visual condition of the pavement. Hence, to estimate PCI either one can follow a manual walkthrough where the condition of the pavement is being noted by the rating panel or a videography of the complete highway section which can be processed separately to estimate the PCI. Any vehicle fitted with laser profilometer used to evaluate roughness, can also be used to get the information of distresses by placing few cameras just like the one shown in **Fig. 5**.

Fig. 5 Typical Vehicle to Measure Roughness as well as Identify Distresses

PCI varies from 0 to 100, 100 being highest quality of road and when it goes down, it shows the deterioration of the pavement. As mentioned above, it is based on the visual condition of the road. While panel is reviewing the asset, based on the observed distress they must identify the severity level and extent of a distress. The complete methodology of estimating PCI is given in ASTM D-6433.

PCI for bituminous pavements encompasses distresses like Alligator Cracking, Bleeding, Block Cracking, Bumps and Sags, Corrugation, Depression, Edge Cracking, Reflection Cracking, Lane/ Shoulder Drop off, Long & Trans Cracking, Patching, Polished Aggregate, Potholes, Railroad Crossing, Rutting, Shoving, Slippage Cracking, Swell and Weathering/Ravelling etc.

Similarly, for rigid pavements, it is based on Blow up/Buckling, Corner Break, Divided Slab, Faulting, Joint Seal, Lane/Shoulder, Linear Cracking, Patching (Large), Patching (Small), Polished Aggregate, Pop outs, Pumping, Punch out, Railroad Crossing, Scaling, Shrinkage, Spalling Corner and Spalling Joint etc.

2.2.3.2 Determination of PCI (ASTM D-6433)

- Identify the distress type and correspondingly its severity level and density on the total pavement.
- Deduct Value (DV) shall be determined for each distress type corresponding to combination of severity level and density from the curves given in ASTM D-6433.
- Maximum Corrected Deduct Value (CDV) shall be determined using the following procedure:
  - If none or only one individual deduct value is greater than two, the total value is used in place of the maximum CDV in determining the PCI; If not maximum CDV shall be determined by following steps
  - Individual deduct values shall be arranged in descending order
  - Allowable number of deducts (m) shall be determined by following formula

$$m = 1 + \left(\frac{9}{98}\right)(100 - HDV) \leq 10$$

Where m = allowable number of deducts including fractions (must be less than or equal to 10),

HDV = Highest Individual Deduct Value

- Determine total deduct value by summing up the m highest individual deduct values; if m is more than the total deduct values available then total deduct value will be summation of deduct values.
- Determine q as the number of deducts with a value greater than 2.0.
- Determine the CDV from total deduct value and q by using the correction curve provided in ASTM D-6433.
- Reduce the smallest deduct value to greater than 2.0 to 2.0 and repeat above two points until q becomes one and CDV shall be determined iteratively.
- Maximum CDV is determined from all the CDV's.

- PCI shall be calculated by deducting maximum CDV from 100 **(PCI = 100-max CDV)**

The same procedure shall also be adopted for rigid pavement to determine PCI.

2.2.3.3 Rating System

PCI determined based on the severity level and extent of distress shall be mapped with the standard PCI rating scale shown in below **Fig. 6**.

Based on the standard PCI rating scale, PCI is to be found out and the number is adjusted to a scale of 10. This will be the rating of the asset in terms of PCI.

Fig. 6: Standard PCI Rating Scale

2.2.4 *Skid Resistance*

Skid resistance is the force developed when a tire that is prevented from rotating slides along the pavement surface (Highway Research Board, 1972). It is an important parameter in pavement which must be evaluated properly to avoid skid related accidents.

Skid resistance of a pavement mainly depends on the pavement surface's micro-texture and macrotexture. Micro-texture refers to the small-scale texture of the pavement aggregate component (which controls contact between the tire rubber and the pavement surface) while macrotexture refers to the large-scale texture of the pavement due to the aggregate particle

arrangement (which controls the escape of water from under the tire and hence the loss of skid resistance with increased speed) (AASHTO, 1976). Skid resistance changes over time. Typically, it increases in the first two years following construction as the roadway is worn away by traffic and rough aggregate surfaces become exposed, then decreases over the remaining pavement life as aggregates become more polished. Skid resistance is also typically lower in the monsoon and winter seasons and higher in the summer. Hence, the measured skid resistance must be adjusted with seasonal variation to avoid wrong indication of the pavement surface.

Skid resistance is generally quantified using friction factor or skid number.

$$Friction\ factor\ (f) = \frac{F}{L}$$

$$Skid\ number\ (SN) = 100 \times f$$

Where,

F is frictional resistance to motion in plane of interface

L is load perpendicular to interface

The tests to determine friction factor must be conducted with standard tires and specified environmental conditions to avoid discrepancy in the results as the frictions tests involve two bodies. Hence, with change in conditions the results will be different. In general, friction resistance will be greater on a dry pavement when compared to a wet pavement.

2.2.4.1 Measurement Method

Skid resistance could be measured in several ways. Out of which, the most widely used and accepted measuring tools are as follows:

i) The locked Wheel Tester **(Fig. 7)**
ii) The Spin up Tester
iii) Surface Texture Measurement Device **(Fig. 8)**
iv) Sideways Force Skid Resistance Survey Devices
v) Fixed Slip Devices

Fig. 7 Locked Wheel Tester

Fig. 8 Surface Texture Measurement Device

In the above-mentioned methods, except surface texture measurement in all the methods/tools skid resistance is calculated. But in surface texture measurement, texture shall be estimated using different tests like Sand Patch test, Road Surface Analyzer (ROSAN) or Class I Profilometer. The measured surface texture is then converted to the skid resistance using the well-established relations.

It is to be noted that the testing methods to estimate skid resistance is not only limited to the above tools/methods; any better method/tool compared to above could also be used.

2.2.4.2 Rating Scale

The rating points based on the measured skid numbers are as follows:

- 10 points; if SN is greater than 60
- 1-point reduction with every 1 SN reduction from 60
- 0 points; if SN is less than 50

2.2.5 *Overall Pavement Rating*

The overall rating for pavement shall be estimated by taking weighted average of all the parameters listed above (roughness, structural condition, PCI and skid resistance) by taking the following weights for each parameter and the weights for each parameter are given in **Table 5**.

Table 5 Weightages for Different Pavement Parameters

Parameter	Weightage
Roughness	20
Structural strength	45
PCI	25
Skid resistance	10

2.3 Embankment

An embankment is earthen material that is placed and compacted below the pavement payers for raising the level of a highway above the surrounding ground surface. Erosion of embankment – particularly – slopes result in pavement failure.

2.3.1 *Parameters*

i) Embankment Slopes
ii) Embankment Protection
iii) Rain Cuts

2.3.2 *Measurement Method*

Visual inspection shall be conducted to determine the condition of the embankments and must be conducted on a sampling basis. Embankment shall be examined for randomly chosen 1m in every 100 m length of the embankment. Geo tagged video recording shall be carried out along with the visual observation of the panel.

2.3.3 *Rating System*

Rating system for individual parameter of Embankment shall be rated as follows **(Table 6)**:

Table 6 Rating System for Embankment/Slopes

Embankment slopes	• Ten points if side slope is as per the prescribed limit. • Two-point reduction for every 3% variation from the prescribed limit until 15% variation. • Zero points if side slope variation is more than 15% with the prescribed limit. • Average of rating points at all measured points as rating for embankment slope.
Embankment protection	• Ten points if there are proper embankment protection measures observed at all slopes. • If improper embankment protection at any location, zero points will be awarded and similarly points will be given to all the embankment locations (> 3 m) and the final score is adjusted to 10 points. • Average of rating points at all measured points as rating for embankment slope.
Rain cuts	• Ten points if there are no rain cuts observed. • If rain cuts at an embankment location, zero points will be awarded and similarly points will be given to all the high embankment locations (> 3 m) and the final score is adjusted to 10 points. • Average of rating points at all measured points as rating for embankment slope.

2.3.4 *Overall Embankment Rating*

The overall rating for embankment shall be estimated by taking weighted average of ratings of all the parameters listed above with similar weightages (embankment slopes, embankment protection and rain cuts).

2.4 Shoulders

Shoulders are an important element of the highway system, as it helps in providing space for emergency stops, recovery zone for brake down vehicles, support for the pavement, drainage and passage for two wheelers. Shoulders are of two different types i) Paved shoulders and ii) Earthen shoulders.

Testing on paved shoulders are of like that of normal pavement evaluation. Hence, in this section we would talk only about earthen shoulders.

The general failures that happen on earthen shoulders are Edge drop, unevenness, vegetation growth and subgrade failures. Hence, these are the parameters that would be considered during evaluation of shoulders.

2.4.1 *Parameters*

i) Edge Drop
ii) Unevenness
iii) Vegetation Growth

2.4.2 *Measurement Method*

Visual inspection shall be conducted to determine the condition of the shoulders and must be conducted on a sampling basis. Shoulder condition shall be observed at a randomly chosen 1 m in every 100 m length of the Shoulder. Geotagged video recording shall be carried out along with the visual observation of the panel.

2.4.3 *Rating System*

Rating system for individual parameter of shoulder shall be rated as below **(Table 7)**:

Table 7 Rating System for Assessment of Shoulders

Edge drop	• Ten points, if there is no edge drop. • Two-point reduction for every 10 mm drop (with respect to prescribed limit as per applicable codes) in edge until 40 mm. • Zero points if edge drop is more than 40 mm. • Average of rating points at all measured points as rating for edge drop.
Unevenness	• Ten points if there is proper compaction on the shoulder along the project length and zero points for the loosely compacted shoulder section. For example, if 100 measurements are done and if unevenness is observed at 40 locations, the rating for unevenness is 6.

Vegetation growth	• Ten points if there is no vegetation growth observed on the shoulder along the project length and zero points for the section where vegetation is observed. For example, if 100 measurements are done and if vegetation growth is observed at 40 locations, the rating for vegetation growth is 6.

2.4.4 *Overall Shoulder Rating*

The overall rating for shoulder shall be estimated by taking average of ratings of all the parameters listed above (edge drop, unevenness and vegetation growth).

2.5 Kerb

2.5.1 *Parameters*

Parameters to be considered for maintenance rating of Kerb are:

i) Kerb Height
ii) Kerb Painting and Cleanliness
iii) Physical Condition of Kerb

2.5.2 *Measurement Method*

Above parameters of Kerb shall be measured at a randomly chosen 10 m section in every 500 m length of the Kerb. Measurements shall be through automatic digital measurement tools or if measured manually shall be supported by GPS coordinates and video back-up.

2.5.3 *Rating System*

Individual parameters of Kerb shall be rated as given below **(Table 8)**:

Table 8 Rating System for Assessment of Kerb

Kerb Height	• Ten points if Kerb height is within ±2.5% of prescribed Kerb height. • One-point reduction for every ±2.5% or part thereof variation in Kerb height from prescribed height to a minimum of 0 points. For clarity, up to ±2.5% deviation ten points, one-point reduction if Kerb height is in the range ±2.5% to ±5% and zero points for a Kerb height variation of ±27.5%. • Average of rating points at all measured points as rating for Kerb Height.
Kerb Painting and Cleanliness	• Rate on a scale of 0 to 10, with zero being worst and 10 being best (we can include area measurement in this; but it may make measurements very cumbersome. However, video recording of the inspection should be available. • Average ratings of individual points to estimate rating for Kerb painting and cleanliness.

Physical Condition of Kerb	• Interpolate between 0 and 10, with 10 if Kerb is in good condition at all points and 0 if it is broken at all measurement points. For example, if 100 measurements are done and if Kerb is broken at 35 places, the rating for Kerb condition is 6.5.

2.5.4 *Overall Kerb Rating*

The overall rating for kerb shall be estimated by as weighted average of ratings of all the parameters listed above (kerb height, kerb painting and cleanliness and physical condition of kerb).

2.6 Median

A median is a component of roadway separating the two opposite directions of traffic. The width of the median is measured from the inside edges of the carriageway and it depends on the Right of way available.

It is a common practice to plant the shrubs and flowering plants on the median which helps to cutoff the headlight glare from the traffic in opposite direction. It is also important to limit the layout and height of the plantations considering the visibility/sight distance at the horizontal curves.

2.6.1 *Parameters*

i) Number of missing median plants
ii) Height of median plants
iii) Cleanliness

2.6.2 *Measurement Method*

Number of plants along the highway shall be counted and summarized for each kilometer section. These shall be then compared with actual kilometer wise requirements and total missing plants for the highway sections shall be estimated. Measurements shall be through automatic digital measurement tools or if measured manually, shall be supported by video back-up.

Height of all median plants shall be measured at a randomly chosen 50 m long section in every 500 m length of median plantation. Measurements shall be through automatic digital measurement tools or if measured manually shall be supported by photograph/video back-up.

For cleanliness, visual inspection will be conducted to determine condition of the median and shall be conducted on a sampling basis. Measurement shall be for 50 m in every 500 m length of the median. Geotagged video recording shall be done along with the visual observation.

2.6.3 *Rating System*

Individual parameters of Median shall be rated as given below **(Table 9)**:

Table 9 Rating System for Assessment of Median

Number of missing median plants	• Ten points if the number of missing median plants along the highway are less than or equal to 1%. • Zero points, if number of median plants missing along the highway are 10% or more. Interpolate for missing median plants between 1 and 10%. i) Height of Median plants
Height of median plants	• For the highway having width of the median>2.5 m, it is suggested to maintain the plantations at a height of 1.5 m. ***(Cl 11.2.4, IRC:SP:84-2019)*** • Ten points if the height of 90% of plants surveyed is within -40% to +20% variation from prescribed height (1.2 to 1.5 m) • Zero points if height of the plantation is more than the prescribed height For example, if 100 measurements are done and if the height of the plantation is not within the prescribed limit at 35 places, the rating for plantation is 6.5.
Cleanliness	• Rate on a scale of 0 to 10, with zero being worst and 10 being best (we can include area measurement in this; but it may make measurements very cumbersome). • Average ratings of individual points to estimate rating for Median cleanliness.

2.6.4 *Overall Median Rating*

The overall rating for median shall be estimated by taking average of ratings of all the parameters listed above (number of missing plants, height of median plants and cleanliness).

2.7 Drainage

Highway drainage plays a critical role in terms of safety of users (as it has a direct relation to the skid characteristics and visibility during rainy days) and maintaining proper pavement quality (water logging on highway lead to distresses like raveling, potholes, etc.). Hence, maintaining proper drainage system is very important.

The main functions of highway drainage include removal of water from the road surface, prevent ingress of water into pavement, pass water across the road and prevent scour and/or washout of the pavement and shoulders.

2.7.1 *Parameters*

i) Camber

ii) Physical Condition of Drain

iii) Cleanliness of Drain

iv) Functional Condition of Drain

2.7.2 *Measurement Method*

Camber shall be measured by taking levels along the highway at a measurement interval not less than 100 m in 1 km length of highway; whereas visual inspection shall be carried out to understand the physical condition and cleanliness of the drain.

For physical condition, cleanliness and functionality of drain measurements shall be carried out at minimum 5 locations spread at maximum 200 m spacing within each section of drain.

2.7.3 *Rating System*

Rating system for individual parameter of shoulder shall be rated as below **(Table 10)**:

Table 10 Rating System for Assessment of Drainage

Camber	• Ten points if camber is 2.5% • Two-point reduction for every 0.05% variation from the prescribed limit (i.e., 2.5%) • Zero points if variation is more than 0.25% with the prescribed limit • Average of rating points at all measured points as rating for Camber
Physical Condition of drain	• Rate in scale on 0 and 10, with 10 if lined drain is in good condition at measurement point and 0 if it is broken/damaged at measurement point. • For example, if 100 measurements are done and if lined drain is broken at 35 places, the rating for physical condition of drain is 6.5.
Cleanliness of drain	• Rate on a scale of 0 to 10, with zero being worst and 10 being best • Average ratings of individual points to estimate rating of cleanliness of drain.
Functionality of drain	• All the drains shall be continuous and there shall not be any blockage of drain. • Rate on a scale of 0 to 10, with 10 if the drain is fully functional (without any blockage till outlet) and with 0 if the drain section is non-functional (measurement shall be done for all drain locations). There will not be any intermediate rating. • For example, if 100 measurements are done and if drain is non-functional at 35 places, the rating for functionality of drain is 6.5.

2.7.4 *Overall Drainage Rating*

The overall rating for drainage shall be estimated by taking weighted average of all the parameters listed above (camber, physical condition of drain, cleanliness of drain and functional condition of drain) by taking the following weights for each parameter and the weights for each parameter are given in **Table 11**.

Table 11 Weightages for Different Drainage Parameters

Parameter	Weightage
Camber	30
Physical condition of drain	15
Cleanliness of drain	15
Functional condition of drain	40

2.8 Overall Rating of Roadway

The overall rating for roadway shall be estimated by taking weighted average of all the different assets considered under roadway by taking the following weights for each parameter and the weights for each parameter are given in **Table 12**.

Table 12 Weightages of Different Assets under Roadway

Asset	Weightage
Pavement	50
Embankment	10
Shoulder	10
Kerb	10
Median	10
Drainage	10

SECTION 3

ASSET RATING OF ROAD SIGNAGE AND FURNITURE – MAINTENANCE

3.1 Introduction

Road furniture is a collective term used for the assets installed on the Highways in order to improve the safety and guide the users along the Highway. In order to rate the Road furniture, it is necessary to evaluate individual components and its parameters separately.

3.2 Pavement Markings

3.2.1 *Parameters*

Parameters to be considered for maintenance rating of Pavement Markings are:

i) Wear and Tear
ii) Luminance Coefficient
iii) Retro-reflectivity (Dry and Wet)
iv) Skid Resistance

3.2.2 *Measurement Method*

Above parameters of Pavement Markings shall be measured along entire length with randomly selected sampling through automatic digital measurement tools or where measured manually shall be supported by GPS coordinates and video back-up. Performance Based Assessment shall be carried out as per IRC:35.

3.2.3 *Rating System*

Individual parameters of Pavement Marking shall be rated as given below **(Table 13)**:

Table 13 Rating System for Assessment of Pavement Markings (refer IRC:35)

Wear and Tear	**Damage to Pavement Marking:** • Less than 5% of area based on measurement as per IRC:35: 10 points. • For every 2.5% over 5%: reduce 1 point till a minimum of zero.
Luminance Coefficient	• Less than 5% of measurements are below the Threshold Level as per IRC:35: 10 points. • For every 2.5% over 5% of measurements which are below the Threshold Level as per IRC:35: reduce 1 point till a minimum of zero.
Retro-Reflectivity (Dry and Wet)	• Less than 5% of measurements are below the Threshold Level as per IRC:35-2015: 10 points. • For every 2.5% over 5% of measurements which are below the Threshold Level as per IRC:35: reduce 1 point till a minimum of zero.

Skid Resistance	• Less than 5% of measurements are above the Threshold Level as per IRC:35: 10 points. • For every 2.5% over 5% of measurements which are above the Threshold Level as per IRC:35: reduce 1 point till a minimum of zero.

3.2.4 *Overall Pavement Markings Rating*

The overall rating for pavement markings shall be estimated by taking average of ratings of all the parameters listed above (wear and tear, daytime visibility, nighttime visibility and skid resistance).

3.3 Signboards

3.3.1 *Parameters*

Parameters to be considered for maintenance rating of Signboards are:

i) Signboards Cleanliness
ii) Physical condition of Signboards
iii) Retro-reflectivity of Signboards

3.3.2 *Measurement Method*

Above parameters of Signboards shall be measured for each Signboard. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video backup. It should also be noted to identify the colour of the measured signboard using chromaticity coordinates.

The retro-reflective surface of signboard after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection as per IRC:67. This shall be determined in accordance with ASTM D 4956-09: Standard Specification for Retroreflective Sheeting for Traffic Control.

3.3.3 *Rating System*

Individual parameters of Signboard shall be rated as given below **(Table 14)**:

Table 14 Rating System for Assessment of Signboard

Signboard Cleanliness	• Rate on a scale of 0 to 10, with zero being worst (i.e., all Signboards have cleaning issues) and 10 being best (all glazers are in good condition) • For example, if 100 signboards are observed along the highway and there are 25 signboards have issues with cleanliness, then rating for cleanliness of Signboards is 7.5.
Physical Condition of Signboard	• Interpolate between 0 and 10, with 10 if all Signboards are in good condition and 0 if all Signboards are broken. For this, both Signboard plate and support shall be considered.

	• For example, if 100 signboards are observed along the highway and there are 25 signboards have damaged physical components, then rating for physical condition of Signboards is 7.5.
Retro-reflectivity of Signboards	• Rate on a scale of 0 to 10, with zero being worst (i.e., all signboards have issues with Retro-reflectivity) and 10 being best (all Signboards have minimum required retro-reflectivity as per IRC:67). • For example, if 100 signboards are observed along the highway and there are 25 signboards have retro-reflectivity less than threshold limit as per IRC:67, then rating for Retro-reflectivity of Signboards is 7.5.

3.3.4 *Overall Signboards Rating*

The overall rating for signboards shall be estimated by taking average of ratings of all the parameters listed above (signboards cleanliness, physical condition of signboards and Retro-reflectivity of Signboards).

3.4 Traffic Blinkers/Signals

3.4.1 *Parameters*

Parameters to be considered for maintenance rating of Traffic Blinkers/Signals are:

i) Traffic Blinkers/Signals Cleanliness
ii) Physical Condition of Traffic Blinkers/Signals
iii) Visibility of Traffic Blinkers/Signals

3.4.2 *Measurement Method*

Above parameters of Traffic Blinkers/Signals shall be measured for each Traffic Blinkers/Signal. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.4.3 *Rating System*

Individual parameters of Traffic blinkers/Signal shall be rated as given below **(Table 15)**:

Table 15 Rating System for Assessment of Traffic Blinkers/Signal

Traffic blinkers/Signal Cleanliness	• 10 points for Traffic Blinkers/Signals in good condition and 0 for Traffic blinkers/Signals have cleaning issues. • Average rating for all the blinkers shall be estimated.
Physical Condition of Traffic blinkers/Signal	• 10 points for Traffic Blinkers/Signals in good condition and 0 for Traffic Blinkers/Signals in broken/damaged/non-functional. For this, both Traffic Blinkers/Signal plate and support shall be considered.

	• Average rating for all the Blinkers shall be estimated.
Visibility of Traffic blinkers/Signals	• 10 points for Traffic Blinkers/Signals having good day/night visibility and 0 for Traffic blinkers/Signals have issues with day/ night visibility. • Average rating for all the Blinkers shall be estimated.

3.4.4 *Overall Traffic Blinkers/Signals Rating*

The overall rating for traffic Blinkers/Signals shall be estimated by taking average of ratings of all the parameters listed above (traffic Blinkers/Signals cleanliness, physical condition of traffic blinkers/signals and visibility of traffic Blinkers/Signals).

The overall rating for traffic Blinkers/Signals shall be estimated by taking weighted average of ratings of all the parameters listed above. For the purpose of overall rating 10% weightage shall be given for traffic Blinkers/Signals cleanliness and 40% of weightage for physical condition and 50% of weightage for visibility of traffic Blinkers/Signals.

3.5 Highway Lighting

3.5.1 *Parameters*

Parameters to be considered for maintenance rating of Highway Lighting are:

i) Illumination

ii) Physical Condition of Lighting

3.5.2 *Measurement Method*

Above parameters of Highway Lighting shall be measured for entire length of Highway. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up. Each section of highway lighting shall be measured and section wise rating shall be estimated, which later shall be converted to Overall Rating for Highway Lighting.

3.5.3 *Rating System*

Individual parameters of Highway Lighting shall be rated as given below **(Table 16)**:

Table 16 Rating System for Assessment of Highway Lighting

Illumination	• 10 points for specified Lux level for the measurements done. • Reduction of 1 point till zero for reduction of every 2.5% in Lux level for the measurements done.
Physical Condition	• 10 points is all lights are working. • Reduction of 1 point till zero for every 2.5% failure of bulbs.

3.5.4 *Overall Highway Lighting Rating*

The overall rating for highway lighting shall be estimated by taking average of ratings of all the parameters listed above (illumination and physical condition of lighting).

3.6 Safety Barriers

3.6.1 *Parameters*

Parameters to be considered for assessing rating of Safety Barriers are:

i) Barrier cleanliness
ii) Physical condition of Barrier
iii) Missing End Treatments and connections between different types of barriers

3.6.2 *Measurement Method*

Above parameters of Safety Barrier shall be measured in linear length. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.6.3 *Rating System*

Individual parameters of Barriers shall be rated as given below **(Table 17)**:

Table 17 Rating System for Assessment of Barriers

Barrier Cleanliness	• 10 points for clean condition of barrier length and 0 points for length having issues with cleanliness. • Overall ratings for Barrier cleanliness to be estimated for entire length. For example, if 100 km of barrier is observed and if Barrier is unclean at 35 km, the rating for Barrier cleanliness is 6.5.
Physical Condition of Barrier	• 10 points for good condition of barrier length and 0 points for broken length. For example, if 100 km of barrier is observed and if Barrier is broken at 35 km, the rating for Barrier condition is 6.5.
Missing End Treatments and connections between different types of barriers	• 10 points, if Barrier end treatment or connections with other types of barrier is in good condition and 0, if it is damaged or improper or missing. • For example, if 100 start-end points and connections with other barriers are observed along the highway and there are is damaged/improper/missing at 35 locations, then rating for Barrier End Treatment is 6.5.

3.6.4 *Overall Barriers Rating*

The overall rating for barriers shall be estimated by taking weighted average of ratings of all the parameters listed above. For the purpose of overall rating 20% weightage shall be given for barrier cleanliness and 40% of weightage for physical condition of barrier and 40% of weightage for Missing End Treatments and connections between different types of barriers.

3.7 Guardrails

3.7.1 *Parameters*

Parameters to be considered for maintenance rating of Guardrails are:

i) Guardrail cleanliness
ii) Physical condition of Guardrail

3.7.2 *Measurement Method*

Above parameters of Guardrail shall be measured in liner length. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.7.3 *Rating System*

Individual parameters of Guardrails shall be rated as given below **(Table 18)**:

Table 18 Rating System for Assessment of Guardrail

Guardrail Painting and Cleanliness	• 10 points for clean condition of length of guardrail and 0 points for length having issues with painting and cleanliness. • Overall ratings for guardrail painting and cleanliness to be estimated for entire length. For example, if 100 km of guardrail is observed and if Barrier is unclean at 35 km, the rating for guardrail painting and cleanliness is 6.5.
Physical Condition of Guardrail	• 10 points for good condition of length of guardrail and 0 points for broken/damaged/improper length. For example, if 100 km of guardrail is observed and if guardrail is broken/damaged/improper at 35 km, the rating for guardrail condition is 6.5.

3.7.4 *Overall Guardrails Rating*

The overall rating for guardrails shall be estimated by taking weighted average of ratings of all the parameters listed above. For the purpose of overall rating 30% weightage shall be given for guardrail painting and cleanliness and 70% of weightage for physical condition of guardrail.

3.8 Antiglazers

3.8.1 *Parameters*

Parameters to be considered for maintenance rating of Antiglazers are:

i) Antiglazer cleanliness
ii) Physical condition and functioning of Antiglazer

3.8.2 *Measurement Method*

Above parameters of Antiglazer shall be measured for each Glazer. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.8.3 *Rating System*

Individual parameters of Antiglazer shall be rated as given below **(Table 19)**:

Table 19 Rating System for Assessment of Antiglazer

Antiglazer Cleanliness	• 10 points for Antiglazer in good condition and 0 for Antiglazer have cleaning issues. • Average rating for all Antiglazer shall be estimated.
Physical Condition and functioning of Antiglazer	• 10 points for Antiglazer in good condition and functioning the purpose of restricting headlights glare and 0 for Antiglazer in broken/damaged/missing. • Average rating for all Antiglazer shall be estimated.

3.8.4 *Overall Antiglazer Rating*

The overall rating for guardrails shall be estimated by taking weighted average of ratings of all the parameters listed above. For the purpose of overall rating 30% weightage shall be given for Antiglazer cleanliness and 70% of weightage for physical condition and functioning of Antiglazer.

3.9 Footpath

3.9.1 *Parameters*

Parameters to be considered for maintenance rating of Footpath are:

i) Footpath encroachments
ii) Footpath cleanliness
iii) Physical condition of the Footpath

3.9.2 *Measurement Method*

Above parameters of Footpath shall be measured continuously. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.9.3 *Rating System*

Individual parameters of Footpath shall be rated as given below **(Table 20)**:

Table 20 Rating System for Assessment of Footpath

Footpath Encroachments	• No portion of footpath is encroached - Ten points • 10% or more of footpath encroached - Zero points Linear interpolation for encroachments between zero and 10%.
Footpath Cleanliness	• 10 points for clean condition of length of footpath and 0 points for length having issues with cleanliness. • Overall ratings for footpath cleanliness to be estimated for entire length.
Physical Condition of Footpath	• Assess condition of footpath at every 10 m interval for surface evenness and physical condition intended to serve the purpose Interpolate between 0 and 10 for rating, with 10, if footpath is in good condition at all points and 0, if it is broken/uneven at all measurement points For example, if 100 measurements are done and if footpath is uneven/broken at 35 places, the rating for footpath condition is 6.5.

3.9.4 *Overall Footpath Rating*

The overall rating for footpath shall be estimated by taking average of ratings of all the parameters listed above (footpath encroachments, footpath cleanliness and physical condition of footpath).

3.10 Separator

3.10.1 *Parameters*

Parameters to be considered for maintenance rating of Separator are:

i) Separator Height
ii) Separator Cleanliness
iii) Physical Condition of Separator

3.10.2 *Measurement Method*

Above parameters of Separator shall be measured in intervals of 10 m. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.10.3 *Rating System*

Individual parameters of Separator shall be rated as given below **(Table 21)**:

Table 21 Rating System for Assessment of Separator

Separator Height	• Ten points, if Separator height is within ±2.5% of prescribed Separator height. • One-point reduction for every 2.5% reduction in Separator height from prescribed height to a minimum of 0 points. For clarity, up to 2.5% deviation 10 points, one-point reduction if reduction in Separator height is in the range 2.5% to 5% and 0 points for a Separator height reduction of 27.5%. • Average of ratings of individual points for rating of Separator height.
Separator Cleanliness	• 10 points for clean condition of length of separator and 0 points for length having issues with cleanliness. • Overall ratings for separator cleanliness to be estimated for entire length.
Physical Condition of Separator	• Interpolate between 0 and 10, with 10 if Separator is in good condition at all points and 0, if it is broken at all measurement points For example, if 100 measurements are done and if Separator is broken at 35 places, the rating for Separator condition is 6.5.

3.10.4 *Overall Separator Rating*

The overall rating for separator shall be estimated by taking average of ratings of all the parameters listed above (separator height, separator cleanliness and physical condition of separator).

3.11 Noise Barriers

3.11.1 *Parameters*

Parameters to be considered for maintenance rating of Noise Barriers are:

i) Physical Condition

3.11.2 *Measurement Method*

Above parameter of Noise Barriers shall be measured for linear length. Measurements shall be through automatic digital measurement tools or through Network Survey Vehicle capable of Inventory Inspection or if measured manually shall be supported by GPS coordinates and video back-up.

3.11.3 *Rating System*

i) 10 points, if entire length of Noise Barrier is in good condition.
ii) Reduction of 1 point for every 2.5% length of broken Noise Barriers.

3.12 Object Markers

3.12.1 *Parameters*

Parameters to be considered for maintenance rating of Object Markers are:

i) Cleanliness
ii) Physical Condition
iii) Night Visibility

3.12.2 *Measurement Method*

Above parameters of Object Markers shall be measured for each Object Marker. Measurements shall be through automatic digital measurement tools or if measured manually shall be supported by GPS coordinates and video back-up.

3.12.3 *Rating System*

Individual parameters of Object Marker shall be rated as given below **(Table 22)**:

Table 22 Rating System for Assessment of Object Marker

Cleanliness	• 10 points for Object Marker in good condition and 0 for Object Marker have cleaning issues. • Average rating for all the Object Markers shall be estimated.
Physical Condition	• 10 points for Object Marker in good condition and 0 for Object Marker in broken/damaged. • Average rating for all the Object Markers shall be estimated.
Night Visibility	• 10 points for Object Marker having good night visibility and 0 for Object Markers have issues with night visibility. • Average rating for all the Object Markers shall be estimated.

3.12.4 *Overall Object Marker Rating*

The overall rating for Object Marker shall be estimated by taking weighted average of ratings of all the parameters listed above. For the purpose of overall rating 10% weightage shall be given for Object Marker cleanliness and 40% of weightage for physical condition of Object Marker and 50% of weightage for night visibility of Object Markers.

3.13 Overall Rating of Road Signage and Furniture

The overall rating for road signage and furniture shall be estimated by taking weighted average of all the different assets considered under roadway by taking the following weights for each

parameter and the weights for each parameter are given in **Table 23**.

Table 23 Weightages of Different Assets under Road Signage and Furniture

Asset	Weightage
Pavement Marking	15
Sign Board	15
Traffic Blinker/Signal	5
Highway Lighting	10
Safety Barriers	20
Guardrail	5
Antiglazer	5
Footpath	5
Separator	5
Noise Barriers	2.5
Object Marker	12.5

SECTION 4

ASSET RATING OF STRUCTURES – MAINTENANCE

4.1 Introduction

Highway structures have different components and each of the component has its own importance for safe and reliable operation of structure. Hence, to evaluate structures, it is necessary to evaluate the individual components separately by considering various parameters.

Following could be various structures along the highways:

i) Grade Separated Structures
ii) Major Bridges
iii) Minor Bridges
iv) Culverts

Components for each of the above type of structures and their importance could be different. For Asset Rating of first 3 types of structures listed above, each of the component can be evaluated in a common way depending on availability of the component in the structure.

Upon Individual component rating, individual structure Rating shall be estimated for each of the structure using the following weightages. The combined rating for the individual structure can be obtained multiplying individual component rating with its weightage in the overall performance of the structure. The weightage of each component is presented in **Table 24**.

Table 24 Weightages for Components for Individual Structure Rating

Structure Component	Grade Separators (Percentage)	Major/minor Bridges (percentage)
Wearing coat and Expansion Joints	10	10
Deck Slab	20	20
Beams/Girder of Super structure	15	15
Bearings	15	15
Substructures (Piers)	5	5
Substructures (Abutments)/return wall/wing walls	5	5
Foundations (Spread footings/Raft/Pile foundations) (If different types are present, average of all the foundation ratings shall be considered)	10	10
Protection Works	NA	10
Retaining Walls/RE WALLS	10	NA
Safety Items (shall follow similar methodology specified for clause 3.6)	10	10

Average Rating of Structures for the Project:

Average Rating for Structures (Grade Separators, Major/Minor bridges) along the Project shall be estimated using length-based weightages for each and every structure along the highway asset.

$$\text{Average Rating of Structures} = \frac{\left(\sum_{i=1}^{N} \text{RATING}_i \times \text{LENGTH}_i\right)}{\left(\sum_{i=1}^{N} \text{LENGTH}_i\right)}$$

Above process is illustrated using a sample example:

Summary of Individual Structures Rating (1)	Average Rating of Structures			
	Length of structure (2)	Performance rating of structure (3)	Weighted rating: column 2 x3 (4)	Average rating of structures Sum (4) ÷ sum (2)
a) Grade separators				
Structure -1	40	8	320	
Structure -2	35	7	245	
b) Major brides				
Bridge -1	120	6	720	
Total	195		1285	6.59

Rating for individual Culvert shall be estimated using the Rating parameters given in this Chapter. **Average rating for all Culverts** along the highway asset shall be estimated as average of ratings for individual culverts.

Final rating of structures including Culverts along the highway asset shall be estimated as weighted average of ratings of structures and culverts with 80% and 20% weightage respectively.

4.2 Wearing Coat & Expansion Joint

4.2.1 *Parameters*

Parameters to be considered for maintenance rating of Wearing Coat & Expansion Joint are:

i) Local depressions
ii) Riding quality near Expansion Joint
iii) Physical condition of Joint Sealant such as Elastomer and Bitumen
iv) Physical condition of full expansion joint assembly which includes edge angles embedded in the deck slab

4.2.2 *Measurement Method*

Above parameters of the wearing coat and expansion joint shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools or if measured manually shall be supported by GPS coordinates and video back-up.

4.2.3 *Rating System*

Individual parameters of wearing coat and expansion joint shall be rated as given below **(Table 25):**

Table 25 Rating System for Assessment of Wearing Coat and Expansion Joint

Parameter	Rating
Local depressions	• Ten points, if there are no local depressions (Ex: Pothole). • Zero points, if there are one or more local depressions untreated for more than 24 hours.
Riding Quality near expansion joint	• Smooth riding at expansion joint location can be given performance rating of 10. • Reduce two points for every 1% of failed expansion joints.
Physical Condition of Joint Sealant	• If the joint sealant is in good condition without any water leakage and without any damage of elastomeric sealant, Performance rating can be 10. • Reduce 1 point for every 1% failure of sealant causing water leakage through the joint.
Physical Condition of Joint Fixing Assembly	• If the edge angles are in good condition without any dislocation from the deck slab, the rating can be 10 and can be reduced to 0 if the edge angle damaged and dislodged from deck slab is more than 25% of total length. • Interpolate for intermediate levels of distress.

4.2.4 *Overall Wearing Coat and Expansion Joint Rating*

The overall rating for wearing coat and expansion joint shall be estimated by taking average of all the parameters listed above (local depressions, riding quality near expansion joint, physical condition of joint sealant and physical condition of joint fixing assembly).

4.3 Deck Slab

4.3.1 *Parameters*

Parameters to be considered for maintenance rating of deck slab are:

i) Cracks
ii) Delamination to Primary reinforcement
iii) Spalling of Concrete
iv) Core damage for full depth of Deck Slab
v) Depth of Carbonation (based on Carbonation Test)
vi) Quality of Concrete in Deck Slab (based on UPV/Rebound Hammer Test/IR Test/GPR)
vii) Reinforcement Corrosion (based on Half-cell Potential Method) **(Fig. 9)**
viii) Equivalent Concrete Cube strength (based on Concrete Core Sample Testing)

Rebound Hammer Test

Ultrasonic Pulse Velocity Test (UPV)

Ground Penetrating Radar (GPR)

Impulse Response Test (IR)

Fig. 9 Non-Destructive Tests for Determining Condition of Structure

4.3.2 *Measurement Method*

Above parameters of the deck slab shall be observed across the total length of the structure and across all the structures. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.3.3 *Rating System*

Individual parameters of Deck slab shall be rated as given below **(Table 26)**:

Table 26 Rating System for Assessment of Deck Slab

Parameter	Description	Rating
Cracks	No Symptoms of cracks and any other damage and the age of the structure is below one year	10 points
	Presence of Micro cracks (0.3 mm) at some locations parallel the reinforcement/Micro cracks become evident	8 points
	Extensive Micro cracks (0.3 -1 mm) more pronounced and parallel to reinforcement	6 points
	Micro cracks Changes to Cracks (1-2 mm)	3 points
	Crack Widening/Cracks (2 - 4 mm) along primary reinforcement is evident/Delamination of Concrete in Secondary Reinforcement	1 points

Parameter	Description	Rating
Delamination	No Delamination	10 points
	Delamination starts to primary reinforcement	9 points
	Delamination in wider area	5 points
	Delamination on more than 10% area	0 points
Spalling	No Spalling	10 points
	Spalling due to Primary Reinforcement/Loss of Steel in Secondary Reinforcement, Extensive Delamination/Partial Loss of Section in Rebar	9 points
	Extensive Spalling in Primary Reinforcement/Secondary Reinforcement, Loss of Section in Rebar/Discontinuity	0 point
Core damage for full depth of slab concrete missing	No core damage	10 points
	Over Footpath area	9 points
	Over Main carriageway area	0 point
Depth of Carbonation	If depth of carbonation is less than the 20% of clear cover	10 points
	If the depth of carbonation is above 90% of clear cover	0 point
Quality of Concrete in deck slab	If the concrete quality is classified is Excellent in UPV test and RHT	10 points
	If the concrete quality is classified is very poor in UPV test and RHT	0 point
Reinforcement Corrosion	If the potential level less than 200 the percentage chance of corrosion probability is 10%	10 points
	If the potential level more than 500 the percentage chance of corrosion probability is 95%	0 point
Equivalent Concrete Cube strength	If the compressive strength of core sample tested is 85% and above of design cube strength.	10 points
	If the compressive strength of core sample tested is 80% and below of design cube strength.	0 point

4.3.4 *Overall Deck Slab Rating*

The overall rating for deck slab shall be estimated by taking weighted average of all the parameters listed above (cracks, delamination, spalling of concrete, core damage, depth of carbonation, quality of concrete in deck slab, reinforcement corrosion and equivalent concrete cube strength) by taking the following weights for each parameter and the weightages for each parameter are given in **Table 27**.

It may be noted that, irrespective of weightages, if three or more parameters mentioned below gets zero rating, complete rating of Deck Slab shall be rated zero.

Table 27 Weightages for Different Deck Slab Parameters

Parameter	Weightage
Cracks	13
Delamination	17
Spalling of Concrete	35
Core Damage	15
Depth of Carbonation	5
Quality of Concrete in Deck Slab	5
Reinforcement Corrosion	5
Equivalent Concrete Cube Strength	5

4.4 Beams/Girder of Superstructure

4.4.1 *Parameters*

Parameters to be considered for maintenance rating of beams/girder of super structure are:

i) Micro cracks
ii) Delamination to Primary reinforcement
iii) Spalling
iv) Depth of Carbonation (Based on Carbonation Test)
v) Quality of Concrete (Based on UPV/Rebound Hammer Test)
vi) Reinforcement Corrosion (Based on Half-Cell Potential Method)
vii) Equivalent Concrete Cube strength (Based on Concrete Core Sample Testing)

4.4.2 *Measurement Method*

Above parameters of the Beams/Girder of Superstructure shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.4.3 *Rating System*

Individual parameters of Beams/Girder of Superstructure shall be rated as given below **(Table 28)**:

Table 28 Rating System for Assessment of Beams/Girder of Superstructure

Parameter	Rating
Cracks	No visible cracks, rating can be 10 and reduced to zero with cracks over 10% of total surface area of beams and girders. Interpolate for intermediate values.

Parameter	Rating
Delamination	Rating starts with 10 for girders with no signs of delamination, shall be reduced to zero for beams having significant delamination over an area of 5% of beam soffit area. Interpolate for intermediate values.
Spalling of concrete	If there is no spalling, the rating can be 10 and falling to zero when spalling of concrete from soffit of beams exceeds 5% of combined beams soffit area. Interpolate for intermediate values.
Depth of Carbonation	If depth of carbonation is less than 20% of clear cover, the rating can be 10 and can be rated as 0 when the depth of carbonation is above 90% of clear cover. Interpolate for intermediate values.
Quality of Concrete in deck slab	If the concrete quality is classified as Excellent in UPV test and RHT, the rating can be 10 points and can be rated as 0 when the concrete quality is classified as very poor in UPV test and RHT. Interpolate for intermediate values.
Reinforcement Corrosion	If the potential level less than 200 the percentage chance of corrosion probability is 10%, the rating can be 10 and can be rated as 0 when the potential level more than 500 the percentage chance of corrosion probability is 95%. Interpolate for intermediate values.
Equivalent Concrete Cube strength	If the compressive strength of core sample tested is 85% and above of design cube strength, the rating can be 10 and can be rated as 0 when the compressive strength of core sample tested is 85% and above of design cube strength. Interpolate for intermediate values.

4.4.4 *Overall Beams/Girder of Superstructure Rating*

The overall rating for beams/girders of super structure shall be estimated by taking weighted average of all the parameters listed above (cracks, delamination, spalling of concrete, depth of carbonation, quality of concrete in deck slab, reinforcement corrosion and equivalent concrete cube strength) by taking the following weights for each parameter and the weights for each parameter are given in **Table 29**.

Table 29 Weightages for Different Beams/Girders of Superstructure Parameters

Parameter	Weightage
Cracks	15
Delamination	25
Spalling of Concrete	40

Parameter	Weightage
Depth of Carbonation	5
Quality of Concrete in Deck Slab	5
Reinforcement Corrosion	5
Equivalent Concrete Cube Strength	5

4.5 Bearings

4.5.1 *Parameters*

Parameters to be considered for maintenance rating bearings are:

i) Physical Damage
ii) Functional Failure

4.5.2 *Measurement Method*

Above parameters of the Bearings shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.5.3 *Rating System*

Individual parameters of Bearings shall be rated as given below **(Table 30)**:

Table 30 Rating System for Assessment of Bearings

Parameter	Rating
Physical Damage	If the Condition of the bearing is new and no visible signs of damaged neoprene/Elastomer/roller, the rating can be given as 10 and the rating can be varied to 0 if the bearing appears completely damaged such as crushed elastomeric bearing, broken POT bearings.
Functional Failure	Performance rating of 10 can be given if the bearing allows design moment and/or rotation. On the other hand, rating can be linearly reduced to 0 if bearing is functionally failed by not allowing any translation or rotation.

4.5.4 *Overall Bearings Rating*

The overall rating for bearings shall be estimated by taking average of all the parameters listed above (physical damage and functional failure).

4.6 Substructure-Piers

4.6.1 *Parameters*

Parameters to be considered for maintenance rating of Piers are:

i) Cracks
ii) Delamination

iii) Spalling
iv) Depth of Carbonation (Based on Carbonation Test)
v) Quality of Concrete (Based on UPV/Rebound Hammer Test)
vi) Reinforcement Corrosion (Based on Half-Cell Potential Method)
vii) Equivalent Concrete Cube Strength (Based on Concrete Core Sample Testing)

4.6.2 *Measurement Method*

Above parameters of the Substructure-Piers shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.6.3 *Rating System*

Individual parameters of Substructure-Piers shall be rated as given below **(Table 31)**:

Table 31 Rating System for Assessment of Substructure-Piers

Parameter	Rating
Cracks	No visible cracks rating can be 10 and reduced to zero with cracks over 10% of total surface area of beams and girders. Interpolate for intermediate values.
Delamination	Rating starts with 10 for girders with no signs of delamination, shall be reduced to 0 for beams having significant delamination over an area of 5% of beam soffit area. Interpolate for intermediate values.
Spalling of concrete	If there is no spalling, the rating can be 10 and falling to 0 when spalling of concrete from soffit of beams exceeds 5% of combined beams soffit area. Interpolate for intermediate values.
Depth of Carbonation	If depth of carbonation is less than 20% of clear cover, the rating can be 9 and can be rated as 1 when the depth of carbonation is above 90% of clear cover. Interpolate for intermediate values.
Quality of Concrete in deck slab	If the concrete quality is classified as Excellent in UPV Test and RHT, the rating can be 10 points and can be rated as 0 when the concrete quality is classified as very poor in UPV Test and RHT. Interpolate for intermediate values.
Reinforcement Corrosion	If the potential level less than 200 the percentage chance of corrosion probability is 10%, the rating can be 10 and can be rated as 0 when the potential level more than 500 the percentage chance of corrosion probability is 95%. Interpolate for intermediate values.

Parameter	Rating
Equivalent Concrete Cube strength	If the compressive strength of core sample tested is 85% and above of design cube strength, the rating can be 10 and can be rated as 0 when the compressive strength of core sample tested is 85% and above of design cube strength. Interpolate for intermediate values.

4.6.4 *Overall Substructure – Piers Rating*

The overall rating for substructure – Piers shall be estimated by taking weighted average of all the parameters listed above (cracks, delamination, spalling of concrete, depth of carbonation, quality of concrete in deck slab, reinforcement corrosion and equivalent concrete cube strength) by taking the following weights for each parameter and the weights for each parameter are given in **Table 32**.

Table 32 Weightages for Different Substructure – Piers Parameters

Parameter	Weightage
Cracks	15
Delamination	25
Spalling of Concrete	40
Depth of Carbonation	5
Quality of Concrete in Deck Slab	5
Reinforcement Corrosion	5
Equivalent Concrete Cube Strength	5

4.7 Substructure-Abutments

4.7.1 *Parameters*

Parameters to be considered for maintenance rating of abutments are:

i) Cracks
ii) Delamination
iii) Spalling
iv) Tilting of Abutment Stem
v) Depth of Carbonation
vi) Quality of Concrete (Based on UPV/Rebound Hammer Test)
vii) Reinforcement Corrosion (Based on Half-Cell Potential Method)
viii) Equivalent Concrete Cube strength (Based on Concrete Core Sample Testing)

4.7.2 *Measurement Method*

Above parameters of the Substructure- Abutments shall be observed across the total length of the structure and across all the structures. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.7.3 *Rating System*

Individual parameters of Substructure-Abutments shall be rated as given below **(Table 33)**:

Table 33 Rating System for Assessment of Substructure-Abutments

Parameter	Rating
Cracks	No visible cracks rating can be 10 and reduced to 0 with cracks over 10% of total surface area of beams and girders. Interpolate for intermediate values.
Delamination	Rating starts with 10 for girders with no signs of delamination, shall be reduced to 0 for beams having significant delamination over an area of 5% of beam soffit area. Interpolate for intermediate values.
Spalling of concrete	If there is no spalling, the rating can be 10 and falling to 0 when spalling of concrete from soffit of beams exceeds 5% of combined beams soffit area. Interpolate for intermediate values.
Tilting of abutment stem due to soil pressure	If the abutment stem tilt is less than 20 mm, rating can be 10 and can be reduced to 0 if the tilting is more than 1.5 times allowable value. Interpolate for intermediate values.
Depth of Carbonation	If depth of carbonation is less than 20% of clear cover, the rating can be 10 and can be rated as 0 when the depth of carbonation is above 90% of clear cover. Interpolate for intermediate values.
Quality of Concrete in deck slab	If the concrete quality is classified as Excellent in UPV Test and RHT, the rating can be 10 points and can be rated as 0 when the concrete quality is classified as very poor in UPV Test and RHT. Interpolate for intermediate values.
Reinforcement Corrosion	If the potential level less than 200 the percentage chance of corrosion probability is 10%, the rating can be 10 and can be rated as 0 when the potential level more than 500 the percentage chance of corrosion probability is 95%. Interpolate for intermediate values.
Equivalent Concrete Cube strength	If the compressive strength of core sample tested is 85% and above of design cube strength, the rating can be 10 and can be rated as 0 when the compressive strength of core sample tested is 85% and above of design cube strength. Interpolate for intermediate values.

4.7.4 *Overall Substructure – Abutments Rating*

The overall rating for substructure – Abutments shall be estimated by taking weighted average of all the parameters listed above (cracks, delamination, spalling of concrete, tilting of abutment stem due to soil pressure, depth of carbonation, quality of concrete in deck slab, reinforcement corrosion and equivalent concrete cube strength) by taking the following weights for each parameter and the weights for each parameter are given in **Table 34**.

Table 34 Weightages for Different Substructure – Abutments Parameters

Parameter	Weightage
Cracks	13
Delamination	17
Spalling of Concrete	35
Tilting of Abutment stem due to soil pressure	15
Depth of Carbonation	5
Quality of Concrete in Deck Slab	5
Reinforcement Corrosion	5
Equivalent Concrete Cube Strength	5

4.8 Foundations- Spread Footings/Rafts

4.8.1 *Parameters*

Parameters to be considered for maintenance rating spread footings/rafts are:

i) Scouring of Foundation Soils
ii) Spalling of Concrete
iii) Settlement and Rotation

4.8.2 *Measurement Method*

Above parameters of the Foundations- Spread footings/Rafts shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by video back-up.

4.8.3 *Rating System*

Individual parameters of Foundations-Spread footings/Rafts shall be rated as given below **(Table 35)**:

Table 35 Rating System for Assessment of Spread Footings/Rafts

Parameter	Rating
Scouring of foundation soils	No scouring of foundation soil can be given performance rating of 10 and reduced to 0 if the scouring is beyond maximum design scour level and 50% of the footing is exposed. Interpolate for intermediate values.

Parameter	Rating
Spalling of Concrete and exposed reinforcement	If the condition of the footing is very good like new performance rating is 10 and linearly reduced to 0 if spalling of concrete is more than 5% of the footing area. Interpolate for intermediate values.
Settlement and rotation	If no settlement or rotation, performance rating can be 10. This can be reduced to 0 if settlement is more than 10 mm over and above allowable limit. Interpolate for intermediate values.

4.8.4 *Overall Foundations – Spread Footing/Rafts Rating*

The overall rating for foundations – spread footing/rafts shall be estimated by taking weighted average of all the parameters listed above (scouring of foundation soils, spalling of concrete and exposed reinforcement, and settlement and rotation) by taking the following weights for each parameter and the weights for each parameter are given in **Table 36**.

Table 36 Weightages for Different Foundations – Spread Footing/Rafts parameters

Parameter	Weightage
Scouring of Foundation Soils	50
Spalling of Concrete and Exposed Reinforcement	30
Settlement and Rotation	20

4.9 Foundations- Pile Foundations

4.9.1 *Parameters*

Parameters to be considered for maintenance rating pile foundations are:

i) Scouring of foundation soils
ii) Scouring of concrete and exposer of steel if incase permanent steel liner is not provided
iii) Tilting and rotation of pile group

4.9.2 *Measurement Method*

Above parameters of the Foundations- Pile foundations shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by video back-up.

4.9.3 *Rating System*

Individual parameters of Foundations-Pile foundations shall be rated as given below **(Table 37)**:

Table 37 Rating System for Assessment of Foundation – Pile Foundation

Parameter	Rating
Scouring of foundation soils	If the scouring is 1m above maximum design scour level for the bridge, performance rating can be considered as 10 and linearly reduced to 1 if the scouring reaches 1m below maximum scour level. Interpolate for intermediate values.
Scouring of concrete and exposer of steel	Performance rating can be 10 if steel linier is provided up to maximum scour level and no physical damage of concrete even after scouring of soil takes place. The rating can be 0 if scouring of concrete is more than 1 sq. meter of surface area with exposer reinforcement for any one of the piles in all group. Interpolate for intermediate values.
Tilting and rotation of pile group.	Performance rating can be 10 if no tilting and rotation is observed in any of the pile foundations in the bridge. The rating can be 0 if tilt is more than 0.380 (1H:150V)

4.9.4 *Overall Foundations – Pile Foundations Rating*

The overall rating for foundations – pile foundations shall be estimated by taking weighted average of all the parameters listed above (scouring of foundation soils and scouring of concrete and exposer of steel) by taking the following weights for each parameter and the weights for each parameter are given in **Table 38**.

Table 38 Weightages for Different Parameters – Pile Foundation

Parameter	Weightage
Scouring of Foundation Soils	30
Scouring of Concrete	40
Tilting and rotation	30

4.10 Well Foundation

4.10.1 *Parameters*

Parameters to be considered for maintenance rating well foundations are:

i) Scouring of soils around well below maximum scour level
ii) Scouring of concrete and exposer of steel reinforcement
iii) Tilting and rotation of well

4.10.2 *Measurement Method*

Above parameters of the Foundations – Well foundations shall be observed across all the foundations for each well foundation. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by video back-up.

4.10.3 *Rating System*

Individual parameters of Foundations-Well foundations shall be rated as given below **(Table 39)**:

Table 39 Rating System for Assessment of Foundations – Well Foundation

Parameter	Rating
Scouring of foundation soils	If the scouring is 1 m above maximum design scour level for the bridge, performance rating can be considered as 10 and linearly reduced to 1 if the scouring reaches 1 m below maximum scour level. Interpolate for intermediate values.
Scouring of concrete and exposer of steel	Performance rating can be 10 if no physical damage of concrete even after scouring of soil takes place. The rating can be 0 if scouring of concrete is more than 1 sq. meter of surface area with exposer reinforcement for any one of the piles in all group. Interpolate for intermediate values.
Tilting and rotation of pile group.	Performance rating can be 10 if no tilting and rotation is observed in well foundation in the bridge. The rating can be 0 if tilt is more than 0 (1H:80V).

4.10.4 *Overall Foundations – Well Foundations Rating*

The overall rating of well foundations shall be estimated by taking weighted average of all the parameters by taking the following weights for each parameter and the weights for each parameter are given in **Table 40**.

Table 40 Weightages for Different Parameters – Well Foundations

Parameter	Weightage
Scouring of Foundation soils and exposure of well lining below maximum scour level	30
Scouring of Concrete in well foundations	40
Tilting of wells beyond acceptable range	30

4.11 Protection Works

4.11.1 *Parameters*

Parameters to be considered for maintenance rating protection works are:

i) Solid apron
ii) Rough stone apron
iii) River guide banks
iv) Quadrant pitching

4.11.2 *Measurement Method*

Above parameters of the Protection Works shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.11.3 *Rating System*

Individual parameters of Protection Works shall be rated as given below **(Table 41)**:

Table 41 Rating System for Assessment of Protection Works

Parameter	Rating
Solid apron	Good condition rating = 10 More than 25% damage, the rating can be reduced to 0. Interpolate for intermediate values.
Rough stone apron	Good condition rating = 10 More than 25% damage, the rating can be reduced to 0. Interpolate for intermediate values.
River guide banks	Good condition rating = 10 More than 25% damage, the rating can be reduced to 0. Interpolate for intermediate values.
Quadratic pitching	Good condition rating = 10 More than 25% damage, the rating can be reduced to 0. Interpolate for intermediate values.

4.11.4 *Overall Protection Works Rating*

The overall rating for protection works shall be estimated by taking weighted average of all the parameters listed above (solid apron, rough stone apron, river guide banks and quadratic pitching) by taking the following weights for each parameter and the weights for each parameter are given in **Table 42**.

Table 42 Weightages for Different Protection Works Parameters

Parameter	Weightage
Solid Apron	50
Rough Stone Apron	20
River Guide Banks	20
Quadratic Pitching	10

4.12 Retaining Walls/Reinforced Earth Structures

4.12.1 *Parameters*

Parameters to be considered for maintenance rating of retaining walls/reinforced earth structures are:

i) Bulging of RE wall
ii) Tilting/Rotation
iii) Cracked RE panels

4.12.2 *Measurement Method*

Above parameters of the Retaining walls shall be observed across the total length of the structure. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.12.3 *Rating System*

Individual parameters of Retaining walls shall be rated as given below **(Table 43)**:

Table 43 Rating System for Assessment of Retaining Walls

Parameter	Rating
Bulging of RE Wall	Rating can be 10 if the bulging of RE wall panels is not more than 10 mm. Rating can be reduced to 0 if more than 5% of RE wall panels have bulging more than 10 mm. Interpolate for intermediate values.
Tilting/Rotation	Rating can be 10 if the RE wall facia panels rotation or tilting is within the permissible limits. If more than 5% of RE wall panels have rotation or tilting exceeding permissible limits rating can be reduced to 0. Interpolate for intermediate values.
Cracked RE Panels	Rating can be 10 if not more than 0.5% of panels are having visible cracks. If more than 5% of RE wall panels have visible cracks the rating can be reduced to 0. Interpolate for intermediate values.

4.12.4 *Overall Retaining Walls/Reinforced Earth Walls Rating*

The overall rating for retaining walls/reinforced earth walls shall be estimated by taking weighted average of all the parameters listed above (bulging of RE walls, tilting/rotation and cracked RE panels) by taking the following weights for each parameter and the weights for each parameter are given in **Table 44**.

Table 44 Weightages for Different Retaining Walls/Reinforced Earth Walls Parameters

Parameter	Weightage
Bulging of RE Walls	60
Tilting/Rotation	30
Cracked RE Panels	10

4.13 Culverts

4.13.1 *Parameters*

Parameters to be considered for maintenance rating of culverts are:

i) Damage of culvert deck slab, pipe barrel and side walls of culvert.
ii) Freeboard
iii) Overtopping
iv) Vent closer with silt and debris
v) Bushes and shrubs in waterway

4.13.2 *Measurement Method*

Above parameters of the Waterway/Culvert Vents shall be observed across the total length of the culverts. Measurements shall be through automatic digital measurement tools (as specified) or if measured manually shall be supported by GPS coordinates and video back-up.

4.13.3 *Rating System*

Individual parameters of Waterway/Culvert vents shall be rated as given below **(Table 45)**:

Table 45 Rating System for Assessment of Culverts

Parameter	Rating
Damage of deck slab, pipe barrel and side walls	Interpolate between 0 and 10, with 10 if deck slab, pipe barrel and side walls are in good condition at all points and 0 if it is broken at all measurement points For example, if 100 measurements are done and if deck slab or pipe barrel or side walls are damaged at 35 places, the rating for this parameter is 6.5.
Freeboard	If the maximum flood level will never exceed designed highest flood level for the cross-drainage structure the rating can be consider 10. This can be reduced & can be 1 if the freeboard is less than 100 mm during every rainy session. Interpolate for intermediate values.
Overtopping	Rating can be 10 if the structure never overtopping and reduced to 1 if the overtopping takes place during every rainy session. Interpolate for intermediate values.

Parameter	Rating
Vent closer with silt and debris	Rating can be 10 if vent is clear and 0 if more than 75% vent is closed with silt and debris.
Bushes and Shrubs	Rating can be 10 if no vegetation and 1 if vent and approach waterway is full of 80% of cross section.

4.13.4 *Overall Waterway/Culvert Vents Rating*

The overall rating for waterway/culvert vents shall be estimated by taking weighted average of all the parameters listed above (freeboard and overtopping) by taking the following weights for each parameter and the weights for each parameter are given in **Table 46**.

Table 46 Weightages for Different Waterway/Culvert Vents Parameters

Parameter	Weightage
Damages to deck slab, pipe barrel and side walls	20
Freeboard	20
Overtopping	30
Vent closer with debris and silt	20
Bushes and Shrubs	10

SECTION 5

ASSET RATING OF TOLL MANAGEMENT SYSTEM (TMS) AND ADVANCED TOLL MANAGEMENT SYSTEM (ATMS) – MAINTENANCE

5.1 Toll Management System

5.1.1 *Introduction*

Toll Management System (TMS) includes different components/tools which are responsible for efficient Toll collections and so in order to rate the Toll management system, it is important to rate each of the component separately.

5.1.2 *Components*

Components to be considered for the rating of the Toll Management System (TMS) are:

i) Traffic Lights
ii) Automatic Boom Barrier
iii) Operator Monitor
iv) Receipt Printer
v) User Fare Display (UFD)
vi) Overhead Lane Status Light (OHLS)
vii) Operator Customized Keyboard
viii) License Plate Indicatory Camera (LPIC)
ix) Document Scan Camera
x) Incident Camera
xi) Automatic Vehicle Classification and Counting System (AVCC)
xii) Weigh in Motion (WIM)
xiii) Static Weigh Bridge (SWB)

5.1.3 *Measurement Method*

Above components of the Toll Management system (TMS) shall be observed across all the lanes of the Toll Plazas that are in operation. Measurements shall be through visual inspection and shall be supported by video back-up.

5.1.4 *Rating system*

Individual components of the Toll Management System (TMS) shall be rated as given below **Table 47**:

Table 47 Rating System for Assessment of Toll Management System (TMS)

Traffic lights	• Rate on a scale of 0 to 10, with 10, if the Traffic lights are in working condition and 0, if they are in non-working condition. • Average of rating points at all measured points as rating for Traffic lights.
Automatic Boom Barrier	• Rate on a scale of 0 to 10, with 10, if the Automatic boom barrier is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Automatic boom barrier.
Operator monitor	• Rate on a scale of 0 to 10, with 10, if the Operator monitor is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Operator monitor.
Receipt Printer	• Rate on a scale of 0 to 10, with 10, if the Receipt printer is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Receipt printer.
User Fare Display (UFD)	• Rate on a scale of 0 to 10, with 10, if the User fare display (UFD) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for User fare display (UFD).
Overhead Lane Status Light (OHLS)	• Rate on a scale of 0 to 10, with 10, if the Overhead lane status light (OHLS) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Overhead Lane Status Light (OHLS).
Operator Customized Keyboard	• Rate on a scale of 0 to 10, with 10, if the Operator customized keyboard is in working condition and 0, if it is in non-working condition.
	• Average of rating points at all measured points as rating for Operator customized keyboard.
License Plate Indicatory Camera (LPIC)	• Rate on a scale of 0 to 10, with 10, if the License Plate Indicatory Camera (LPIC) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for License Plate Indicatory Camera (LPIC).
Document Scan Camera	• Rate on a scale of 0 to 10, with 10, if the Document scan camera is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Document scan camera.

Incident Camera	• Rate on a scale of 0 to 10, with 10, if the Incident camera is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Incident camera.
Automatic Vehicle Classification and Counting System (AVCC)	• Rate on a scale of 0 to 10, with 10, if the Automatic Vehicle Classification and Counting (AVCC) system is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Automatic Vehicle Classification and Counting (AVCC) System.
Weigh in Motion (WIM)	• Rate on a scale of 0 to 10, with 10, if the Weigh in motion (WIM) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Weigh in Motion (WIM).
Static Weigh Bridge (SWB)	• Rate on a scale of 0 to 10, with 10, if the Static Weigh Bridge (SWB) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Static Weigh Bridge (SWB).

5.1.5 *Overall TMS Rating*

The overall rating for TMS shall be estimated by taking average of ratings of all the parameters listed above (Traffic Lights, Automatic Boom Barrier, Operator Monitor, Receipt Printer, UFD, OHLS, Operator Customized Keyboard, LPIC, Document Scan Camera, Incident Camera, AVCC, WIM and SWB).

5.2 Advance Traffic Management System (ATMS)

5.2.1 *Introduction*

Advanced Traffic Management system (ATMS) includes all the outdoor and indoor components which are responsible to indicate the traffic flow and to provide emergency services all round the clock across the Highway.

5.2.2 *Components*

Components to be considered for the rating of the Advanced Traffic Management System (ATMS) are:

i) Video Surveillance System (Pan Tilt Zoom-PLT cameras)
ii) Mobile Radio Communication System
iii) Video Incident Detection System (VIDS)
iv) Vehicle Actuated Speed Display System
v) Emergency Roadside Telephone System
vi) Variable Message Sign (VMS) System
vii) Meteorological Data System (MET)

viii) Automatic Traffic Counter-cum-Classifier

ix) Travel Time Estimation System

5.2.3 *Measurement Method*

Above components of the Advanced Traffic Management System (ATMS) shall be observed across all the length of the highway. Measurements shall be through visual inspection and shall be supported by GPS coordinates and video back-up.

5.2.4 *Rating System*

Individual components of the Advanced Traffic Management System (ATMS) shall be rated as given below **(Table 48)** :

Table 48 Rating System for Assessment of Advanced Traffic Management System (ATMS)

Video Surveillance System (Pan Tilt Zoom-PLT cameras)	• Rate on a scale of 0 to 10, with 10, if the Video surveillance system is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Video Surveillance System.
Mobile Radio Communication system	• Rate on a scale of 0 to 10, with 10, if the Mobile Radio Communication system is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Mobile Radio Communication System.
Video Incident Detection System (VIDS)	• Rate on a scale of 0 to 10, with 10, if the Video Incident Detection System (VIDS) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Video Incident Detection System (VIDS).
Vehicle Actuated Speed Display system	• Rate on a scale of 0 to 10, with 10, if the Vehicle Actuated Speed Display system is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Vehicle Actuated Speed Display System.
Emergency Roadside Telephone System	• Rate on a scale of 0 to 10, with 10, if the Emergency Roadside Telephone System is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Emergency Roadside Telephone System.

Variable Message Sign (VMS) system	• Rate on a scale of 0 to 10, with 10, if the Variable Message Sign (VMS) system is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Variable Message Sign (VMS) System.
Meteorological Data System (MET)	• Rate on a scale of 0 to 10, with 10, if the Meteorological Data System (MET) is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Meteorological Data System (MET).
Automatic Traffic Counter-cum-Classifier	• Rate on a scale of 0 to 10, with 10, if the Automatic Traffic Counter-cum-Classifier is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Automatic Traffic Counter-cum-Classifier.
Travel Time Estimation System	• Rate on a scale of 0 to 10, with 10, if the Travel Time Estimation System is in working condition and 0, if it is in non-working condition. • Average of rating points at all measured points as rating for Travel Time Estimation System.

5.2.5 *Overall ATMS Rating*

The overall rating for ATMS shall be estimated by taking average of ratings of all the parameters listed above (Video Surveillance System, Mobile Radio Communication System, VIDS, Vehicle Actuated Speed Display System, Emergency Roadside Telephone System, VMS, MET, ATCC and Travel Time Estimation System).

5.3 Overall TMS and HTMS/ATMS Rating

The overall rating of TMS and HTMS/ATMS shall be estimated by taking average of both combined rating of TMS and HTMS/ATMS.

SECTION 6

ASSET RATING OF PROJECT FACILITIES – MAINTENANCE

6.1 Introduction

Project Facilities is a collective term used to indicate the facilities available along the highways to facilitate i) efficient operation and maintenance of highway, and ii) user comfort

6.2 Bus Bay

6.2.1 *Parameters*

Parameters to be considered for maintenance rating of Bus Bay are:

i) Physical Condition of Bus Shelter
ii) Condition of Parking Area
iii) Painting of Bus Shelter
iv) Cleanliness of Bus Bay

6.2.2 *Measurement Method*

Above parameters of Bus Bay shall be measured for each of the Bus Bay. Measurements shall be through visual inspection and shall be supported by GPS coordinates and video back-up.

6.2.3 *Rating System*

Individual parameters of Bus Bay shall be rated as given below **(Table 49)** :

Table 49 Rating System for Assessment of Bus Bay

Physical Condition of Bus Shelter	• Rate on a scale of 0 to 10, with 10 being best (all elements like platform, shed, seating arrangement, signboards etc., are in place) and zero being worst (i.e., Bus Bay is not in usable condition at all) • Average of rating points at all measured points as rating for Physical condition of Bus shelter • For example, if 100 measurements are done and if Bus shelter is worse at 35 places, the rating for Physical condition of Bus Shelter is 6.5.
Condition of Parking Area	• Rate on a scale of 0 to 10, with 10 being best (i.e. free from any distress like potholes, cracks, water logging, etc.) and zero being worst. • Average of rating points at all measured points as rating for Condition of Parking Area.

Painting of Bus Shelter	• Rate on a scale of 0 to 10, with 10 being best (i.e. painting is proper) and zero being worst. • Average of rating points at all measured points as rating for Painting of Bus Shelter.
Cleanliness of Bus Bay	• Rate on a scale of 0 to 10, and 10 being best (no littering at all) and with zero being worst. • Average of rating points at all measured points as rating for Cleanliness of Bus Bay.

6.2.4 *Overall Bus Bay Rating*

The overall rating for bus bay shall be estimated by taking average of ratings of all the parameters listed above (physical condition of bus shelter, condition of parking area, painting of bus shelter and cleanliness of bus bay).

6.3 Truck Lay Bye

6.3.1 *Parameters*

Parameters to be considered for maintenance rating of Truck Lay Bye are:

i) Physical Condition of Truck Lay Bye
ii) Cleanliness of Truck Lay Bye

6.3.2 *Measurement Method*

Above parameters of Truck Lay Bye shall be measured for each of the Truck Lay Bye. Measurements shall be through visual inspection and shall be supported by GPS coordinates and video back-up.

6.3.3 *Rating System*

Individual parameters of Truck lay Bye shall be rated as given below **(Table 50)**:

Table 50 Rating System for Assessment of Truck Lay Bye

Physical Condition of Truck Lay Bye	• Rate on a scale of 0 to 10, with 10 being best (all elements like signboards, lighting, etc., are in place and the parking area is free from any distress like potholes, cracks etc.) and zero being worst (i.e., Truck Lay Bye is not in usable condition at all). • Average of rating points at all measured points as rating for Physical condition of Truck Lay Bye.
Cleanliness of Truck Lay Bye	• Rate on a scale of 0 to 10, and10 being best (no littering at all) and with zero being worst. • Average of rating points at all measured points as rating for Cleanliness of Truck Lay Bye.

6.3.4 *Overall Truck Lay Bye Rating*

The overall rating for Truck Lay Bye shall be estimated by taking average of ratings of all the parameters listed above (physical condition of Truck Lay Bye and cleanliness of Truck Lay Bye).

6.4 Toilet Block/Rest Area

6.4.1 *Parameters*

Parameters to be considered for maintenance rating of Toilet Block/Rest Area are:

i) Physical Condition of Building
ii) Cleanliness of Toilet Block
iii) Condition of Basic Amenities
iv) Availability of Maintenance staff

6.4.2 *Measurement Method*

Above parameters of Toilet Block shall be measured for each of the Toilet Block. Measurements shall be through visual inspection and shall be supported by Geotagged video/photographic back-up.

6.4.3 *Rating System*

Individual parameters of Toilet Block shall be rated as given below **(Table 51)**:

Table 51 Rating System for Assessment of Toilet Block

Physical Condition of Building	• Rate on a scale of 0 to 10, with 10 being best (building is in good condition and well painted) and zero being worst (i.e. building requires major civil repairs). • Average of rating points at all measured points as rating for Physical condition of Building.
Cleanliness of Toilet Block	• Rate on a scale of 0 to 10, and10 being best (no littering at all) and with zero being worst. • Average of rating points at all measured points as rating for Cleanliness of Toilet Block.
Condition of Basic Amenities	• Assess condition of all the amenities of Toilet Block (Wash basin, taps, urinals, doors etc.). • All the amenities need shall be classified into working and non-working category. • Rating shall be converted into a scale of 0 to 10, interpolate between 0 and 10, with 10 if all the amenities are in working category and 0 if all the amenities are non-working. • Average of rating points at all measured points as rating for Condition of Basic Amenities.

Availability of Maintenance Staff	• Rate 10 points if Maintenance staff is available at toilet block otherwise 0 points if staff is not available. • Average of rating points at all measured points as rating for availability of maintenance staff.

6.4.4 *Overall Toilet Block/Rest Area Rating*

The overall rating for Toilet Block shall be estimated by taking average of ratings of all the parameters listed above (physical condition of building, cleanliness of toilet block, condition of basic amenities and availability of maintenance staff).

6.5 Overall Project Facilities Rating

The overall rating for project facilities shall be estimated by taking average of all ratings of different facilities considered under Project Facilities.

SECTION 7

RATING OF MISCELLANEOUS ASSETS-MAINTENANCE

7.1 Introduction

Miscellaneous assets include some of the optional and necessary assets made by the concessionaire to facilitate efficient operation and maintenance along the Highway.

7.2 O&M Centre

7.2.1 *Parameters*

Parameters to be considered for maintenance rating of O&M Centre are:

i) Condition of O&M Centre
ii) Safety and Firefighting System
iii) Availability of Basic Construction Equipment

7.2.2 *Measurement Method*

Measurements shall be through visual inspection and shall be supported by video/photographic back-up.

7.2.3 *Rating System*

Individual parameters of O&M Centre shall be rated as given below (**Table 52**):

Table 52 Rating System for Assessment of O&M Centre

Condition of O&M Centre	• Rate on a scale of 0 to 10, with 10 being best (building is in good condition and well painted) and zero being worst (i.e. building requires major civil repairs). • Average of rating points at all measured points as rating for Physical condition of O&M Centre.
Safety and Firefighting System	• Rate on a scale of 0 to 10, and10 being best (Safety and Firefighting Systems are working) and 0 being worst (i.e. if the safety and firefighting System are not working). • Average of rating points at all measured points as rating for Safety and Firefighting System.
Availability of Basic Construction/O&M Equipment	• Assess condition of all the construction/O&M equipment (Roller, Concrete Mixer, JCB, Grass Cutter, etc.). • All the equipment shall be classified into working and non-working category.

	• Rating shall be converted into a scale of 0 to 10, interpolate between 0 and 10, with 10 if all the equipment is in working category and 0 if all the equipment is non-working. • Average of rating points at all measured points as rating for Availability of Basic Construction/O&M Equipment.

7.2.4 *Overall Rating for O&M Centre*

The overall rating for O&M Centre shall be estimated by taking average of ratings of all the parameters listed above (physical condition of O&M Centre, safety and firefighting system and availability of basic construction equipment).

7.3 Material Testing Laboratory

7.3.1 *Parameters*

Parameters to be considered for maintenance rating of Material Testing Laboratory are:

i) Physical Condition of Laboratory
ii) Safety and Firefighting System
iii) Availability of Equipment
iv) Calibration Certificate

7.3.2 *Measurement Method*

Above parameters of Laboratory shall be measured for all the Material Testing Laboratory available at project site. Measurements shall be through visual inspection and shall be supported by video back-up.

7.3.3 *Rating System*

Individual parameters of Laboratory shall be rated as given below **(Table 53)**:

Table 53 Rating System for Assessment of Laboratory

Physical Condition of Laboratory	• Rate on a scale of 0 to 10, with 10 being best (building is in good condition and equipment are well organized) and zero being worst (i.e. building requires major civil repairs). • Average of rating points at all measured points as rating for Physical condition of Laboratory.
Safety and Firefighting System	• Rate on a scale of 0 to 10, and 10 being best (Safety and Firefighting Systems are working) and 0 being worst (i.e. if the safety and firefighting System are not working). • Average of rating points at all measured points as rating for Safety and Firefighting System.

Availability of Laboratory Equipment	• Assess condition of all the equipment by testing them. • All the equipment needs classify into working and non-working category. • Rating shall be converted into a scale of 0 to 10, interpolate between 0 and 10, with 10 if all the equipment is in working category and 0 if all the equipment is non-working. • Average of rating points at all measured points as rating for Availability of Laboratory Equipment.
Calibration Certificate	• Rating on a scale of 0 to 10, interpolate between 0 and 10, with 10 if all the equipment has valid calibration certificate and 0 if all the equipment does not have calibration certificate. • Average of rating points at all measured points as rating for Calibration Certificate.

7.3.4 *Overall Material Testing Laboratory Rating*

The overall rating for material testing shall be estimated by taking average of ratings of all the parameters listed above (physical condition of laboratory, safety and firefighting system, availability of laboratory equipment and calibration certificate).

7.4 Toll Plaza/Administrative Building

7.4.1 *Parameters*

Parameters to be considered for maintenance rating of Toll Plaza/Administrative building are:

i) Physical condition of the Building
ii) Fire Fighting System in the Buildings
iii) Control Center in the Toll Plaza Building

7.4.2 *Measurement Method*

Above parameters of Toll plaza/Administrative building shall be measured for all the Toll plaza buildings across the project site (if multiple Toll Plazas exist) and Administrative building of the Project. Measurements shall be through visual inspection and shall be supported by video back-up.

7.4.3 *Rating System*

Individual parameters of Toll plaza/Administrative Building shall be rated as given below **(Table 54)**:

Table 54 Rating System for Assessment of Toll Plaza/Administrative Building

Physical Condition of building	• Rate on a scale of 0 to 10, with 10 being best (building is in good condition and zero being worst (i.e. building requires major civil repairs). • Average of rating points at all measured buildings as rating for Physical condition of building.
Safety and Firefighting System	• Rate on a scale of 0 to 10, and 10 being best (Safety and Firefighting Systems are working) and 0 being worst (i.e. if the safety and firefighting System are not working). • Average of rating points at all measured points as rating for Safety and Firefighting System.
Control Center	• During a random visit, observe the monitoring process and rate on a scale of 0 to 10 where 10 means Best Practices and 0 indicates Worst Practices and needs considerable improvement.

7.4.4 *Overall Toll Plaza/Administrative Building Rating*

The overall rating for toll plaza/administrative building rating shall be estimated by taking average of ratings of all the parameters listed above (physical condition of building, safety and firefighting system, and control center).

7.5 Landscaping

7.5.1 *Parameters*

Parameters to be considered for rating of Landscaping are:

i) Aesthetic appearance
ii) Documentation of Activity Schedule planned for Avenue Plantation and its maintenance

7.5.2 *Measurement Method*

Above parameters of Landscaping shall be inspected at a randomly chosen 50 m in every 200 m. Measurements shall be through visual inspection and shall be supported by video back-up.

7.5.3 *Rating System*

Individual parameters of Landscaping shall be rated as given below **(Table 55)**:

Table 55 Rating System for Assessment of Landscaping

Aesthetic appearance	• Rate on a scale of 0 to 10, with 10 being excellent, 5 being Good and 0 being Poor • Average of rating points at all measured points as rating for Aesthetic appearance of Landscaping

Documentation of Activity Schedule	• Activity Schedule planned for Avenue plantation and its maintenance is documented-10 points • 0 points, if not documented

7.5.4 *Overall Landscaping Rating*

The overall rating for landscaping shall be estimated by taking average of ratings of all the parameters listed above (aesthetic appearance and documentation of activity schedule).

7.6 Eco-friendly measures

7.6.1 *Parameters*

Parameters to be considered for the rating of Eco-friendly measures are:

i) Use of Solar energy
ii) Implementing Rainwater Harvesting
iii) Any other Eco-friendly measure being implemented

7.6.2 *Measurement Method*

Above parameters of Eco-friendly measures shall be inspected at a randomly chosen 50 m in every 200 m. Measurements shall be through visual inspection and shall be supported by GPS coordinates and video back-up.

7.6.3 *Rating System*

Individual parameters of Eco-friendly measures shall be rated as given below **(Table 56)**:

Table 56 Rating System for Assessment of Eco-friendly Measures

Solar/other Renewable Energy	• Rate on a scale of 0 to 10, with 10 points being solar/renewable energy used on 50% or more on the total length of the Highway. • Reduce 2 points for every 10% reduction in the use of Solar/ renewable energy on the total length of the Highway.
Rainwater Harvesting	Any of the Rainwater Harvesting measure • implemented and in effective use-10 points • implemented but not effective-5 points • not implemented-0 points
Any other Eco-friendly measure	• Any other Ecofriendly measure implemented - 10 points, Else- 0 points

7.6.4 *Overall Eco-friendly Measures Rating*

The overall rating for eco-friendly measures shall be estimated by taking average of ratings of all the parameters listed above (Solar Energy, Rainwater Harvesting and any other Eco-Friendly Measure).

The overall rating for eco-friendly measures shall be estimated by taking weighted average of ratings of all the parameters listed above. For the purpose of overall rating 40% weightage shall be given for solar/other renewable energy and 40% of weightage for rainwater harvesting and 20% weightage for any other eco-friendly measures.

7.7 Overall Miscellaneous Assets Rating

The overall rating for miscellaneous assets shall be estimated by taking weighted average of all the different parameters considered under miscellaneous assets by taking the following weights for each parameter and the weights for each parameter are given in **Table 57**.

Table 57 Weightages of Different Assets under Miscellaneous Assets

Asset	Weightage
O&M Centre	15
Material Testing Laboratory	15
Toll Plaza/Administrative Building	30
Landscaping	20
Eco-Friendly Measures	20

SECTION 8

ASSET RATING OF O&M MANAGEMENT PLANS AND SYSTEMS – OPERATIONS

8.1 Introduction

Implementation of an Internal O&M Management Plan (IMP) or similar document shows organizational commitment towards sustainability and efficiency during O&M Period.

A fully developed internal O&M plan and SOP should contain a performance measurement system that includes goals, performance metrics, quantifiable targets, strategies, and actions designed to help meet the overall objective. The plan can be in the form of a published document, website, brochure, or other format, so long as the elements under the requirement section can be clearly demonstrated.

8.2 Parameters

Parameters to be considered for the rating of O&M Management Plans are:

8.2.1 *Commitment from Operating Agency*

It would include Policy Statement, Executive order, Organizational directive endorsed by senior executives in the operating agency which shows that the company is committed towards continuous performance assessment, evaluation and improvement.

8.2.2 *Internal Management Plan and SOP's*

The IMP and SOP's parameter is a measure of the below 4 components.

a) **Coordination:** IMP should be in line (integrated) with the standards and performance metrics of the Project documents, State/National Policies and Guidelines. It would include the following
   - Involve key stakeholders (Authority, Independent Engineer etc.) in defining missions and goals.
   - Identifying key factors that could significantly affect the achievement of the goals.
   - Align activities, core processes, and resources to help achieve the goals.

b) **Implementation Plan:** The IMP has an implementation section includes SOP's (for Toll Operations, Incident Management, Maintenance etc.), responsible parties and timelines. It will involve development of a set of performance measures at each organizational level that demonstrate results.

c) **Monitoring Plan and SOP's:** The IMP includes a performance measurement system, a plan for monitoring the plan's progress, and a schedule for updating the plan as needed. The organization should collect sufficiently complete, accurate, and consistent data to document performance and support decision making at various organizational levels.

d) **Employee Engagement and Training:** Training on sustainability to be provided for staff, including an introduction to the IMP.

8.2.3 *Outcome Reports*

Monitor progress towards goals at regular intervals after goal establishment and show measurable advancement towards stated goals. Use performance information in systems to achieve performance goals and demonstrate effectiveness of the IMP.

8.3 Measurement Method

Above parameters of O&M Management Plans and Systems shall be measured by verifying the adequate and necessary documents mentioned in **Section 8.2** as against each parameter.

8.4 Rating System

Individual parameters of O&M Management Plans and Systems shall be rated as given below **(Table 58)**:

Table 58 Rating System for Assessment of O&M Management Plans and Systems

Commitment from Operational Agency		• Rate 2 points, if the commitment from Operational agency is found satisfactory, else 0 points
Internal Management Plan (IMP) and SOP's	Coordination	• Rate 1 point, if the coordination is found satisfactory, else 0 points
	Implementation Plan	• Rate 1 point, if the Implementation Plan is found satisfactory, else 0 points
	Monitoring Plan and SOP's	• Rate 1 point, if the Monitoring Plan and SOP's are found satisfactory, else 0 points
	Employee Engagement and Training	• Rate 1 point, if the Employee engagement and Training is provided, else 0 points
Outcome Reports		• Rate 4 points, if the Outcome report is found satisfactory, else 0 points

8.5 Overall O&M Management Plans and Systems Rating

The overall rating for O&M Management Plans and Systems shall be estimated by summing individual points of each parameter.

SECTION 9

ASSET RATING OF TOLL PLAZA – OPERATIONS

9.1 Introduction

The goal is to achieve a consistent strategy for handling potential points of conflict, controlling flow of various vehicle types and conveying information at toll plazas so that safety and operations are enhanced, better efficiency and economy of design are achieved. This must be accomplished in consideration of the fact that each toll facility has its own unique identity.

9.2 Parameters

Parameters to be considered for the rating of Toll Plaza Operations are:

9.2.1 *Efficiency in Tolling Operations*

The efficiency in Tolling Operations can be measured by the below 2 components:

i) Average Waiting Time
ii) Queue Length

9.2.2 *Efficiency in functioning of Electronic Toll Collection (ETC)*

The efficiency in functioning of ETC can be measured by following components:

i) Availability/Condition of ETC in all Toll Lanes
ii) Average operational time of ETC

9.2.3 *User Comfort (Customer, Employees and Visitors)*

a) Performance of Toll Operations Staff:

The following performance factors apply to all staff employees, regardless of job title/level

i) **Functional and Technical Skills:** The effectiveness with which the staff applies the required skills and knowledge to the job.

Rating Elements for the performance of Toll Operations Staff are:

- Demonstrates and applies the knowledge and skills necessary to perform the job effectively.
- Chooses appropriate tools or technology for tasks.
- Understands and complies with position procedures, rules and regulations.
- Acts as a resource upon whom others rely on for assistance and actively shares knowledge to improve operational efficiency.

ii) **Communication Skills:** The effectiveness of the staff in transmitting information, including participation in sharing information, and oral and written expression

Rating Elements for Communication Skills are:

- Demonstrates effective written and oral communication skills.

- Communicates clearly and knowledgeably and appropriately shares information with others.
- Practices active listening, encouraging communication for understanding.

iii) **User Service:** The effectiveness of the employee in providing quality service to users, including demonstrated commitment to improvement of service.

Since, user comfort is more from user perspective, authority may develop a mobile application survey where all the above-mentioned parameters could be asked and based on the responses from users; points shall be awarded. To eliminate the outliers highest 10% as well as lowest 10% results can be ignored while estimating the points in this category.

b) User Information and Traffic Control Devices

Availability of user information boards near toll plaza shall be visually checked and accordingly rating shall be conducted.

9.3 Rating System

Individual parameters of Toll Plaza Operations shall be rated as given below **(Table 59 to 62)**:

Table 59 Rating System for Assessment of Efficiency in Tolling Operations

Parameter	Criteria	Rating
Average Waiting Time	0 to 30 Seconds	5
	30 to 60 Seconds	4
	60 to 120 Seconds	3
	120 to 180 Seconds	2
	More than 180 Seconds	0
Queue Length	Less than 2 Vehicles in Queue at all lanes	5
	2 Vehicles in Queue at all lanes	4
	3 Vehicles in Queue at all lanes	3
	4 Vehicles in Queue at all lanes	2
	5 Vehicles in Queue at all lanes	1
	More than 6 Vehicles in Queue at all lanes	0

Table 60 Rating Scale of Efficiency of ETC

Availability/Condition of ETC	• 5 points, if all toll lanes are provided with hybrid ETC system/ETC. • Reduction of 0.5 point till zero for unavailability of hybrid system or dedicated ETC for each toll lane (If toll lanes are more than 10); if toll lanes are less than 10, rating scale shall be adjusted on prorate basis.
Average operational time	• 5 points, if average operational time is less than 10 sec on any 15 min observation period. • Reduction of 0.5 point till zero for every 1 sec increase in average operational time in the above observation period.

Table 61 Rating System for Assessment of User Comfort (Performance of Toll Operations Staff)

Parameter	Component	Criteria	Rating
Performance of Toll Operations Staff	Functional and Technical Skills	Possesses and applies advanced functional or technical knowledge to his or her job, and process innovation and complex problem solving. Understands and complies with position procedures, rules and regulations. Demonstrates an active interest in enhancing current skills and learning new ones. Acts as a resource upon whom others rely on for assistance and actively shares knowledge to improve performance	5
		Possesses and uses the required knowledge skills and abilities to perform the job effectively. Understands and complies with position procedures, rules and regulations. Demonstrates an active interest in enhancing current skills and learning new ones.	4
		Possesses and uses the required knowledge skills and abilities to perform the job effectively.	3
		Lacks some of the required functional and technical knowledge and skills to perform the job effectively.	2
		Does not exhibit the functional and technical knowledge and skills necessary to perform the job effectively.	1
	Communication Skills	Communication is of the highest quality. Clarifies even difficult issues clearly and concisely. Is quick and positive in response to user queries for input or information. Sets the exemplar of style and tone in communications.	5
		Communications are consistently well executed and appropriate to user requirements. Style and tone consistently promote positive relations and convey a positive image of the operations process.	4
		Communication is consistently clear, timely, and accurate. Communications typically concentrate on the requirements of user. Style and tone are appropriate and respectful of others. Practices attentive and active listening	3
		Communication is not consistently effective. Occasionally communications lack clarity and do not consistently convey required information. Style and tone are not consistently appropriate or respectful.	2

Parameter	Component	Criteria	Rating
		Communication is often unclear, inaccurate, or poorly constructed. Has difficulty conveying the intent or importance of the message. Style or tone is often inappropriate and creates problems with others.	1
	User Service	Exceptional in terms of understanding, improving, and modifying service delivery approach for diverse users and delicate situations.	5
		Dependably and knowledgeably delivers high quality service to users. Shares feedback with the team to continually improve the quality of service to the users.	4
		Regularly and consistently delivers valued service to users, in terms of quality. If unable to assist client, escalates to an appropriate resource.	3
		Does not consistently meet user needs in terms of quality. At times, does not respond to user requests, or escalates, or hands-off users to others even when the request is well within their scope of responsibility.	2
		Frequently fails to deliver quality user service, resulting in complaints. Is frequently irritated with users.	1

Table 62 Rating Scale of User Information

Availability/Condition of User information boards	• 10 points, if user information boards are present in good/legible condition and with updated information at designated points
	• 5 points, if information boards are present as above but not in satisfactory condition
	• 0 points, if the user information boards are absent as well as not in good condition

9.4 Overall Toll Plaza – Operations Rating

The overall rating for toll plaza shall be estimated by taking weighted average of all the different parameters considered under toll plaza by taking the following weights for each parameter and the weights for each parameter are given in **Table 63**.

Table 63 Weightages of Different Parameters under Toll Plaza

Asset	Weightage
Efficiency in Tolling Operations	35
Efficiency in functionality of ETC	35
User Comfort (average of performance of toll operations staff and user information)	30

SECTION 10

ASSET RATING OF EMERGENCY RESPONSE SYSTEM – OPERATIONS

10.1 Introduction

Emergency Response System is an important operation which include several services responding to the emergencies along the Highway. It includes the Route Patrolling Van (RPV), Ambulance, Crane/Recovery vehicles and a centralized management system from the control center.

10.2 Parameters

Parameters to be considered for the rating of Emergency Response System (ERS) or Incident Management System (IMS) are:

i) Past one-year Incident Response time

ii) Functionality of Vehicle Tracking System (VTS): For avoidance of doubts, availability of VTS in all the IMS vehicles i.e., RPV, Ambulance, Crane/Recovery vehicles shall be averaged.

iii) Past one-year Route Patrolling distance

iv) Inventory check of RPV, Ambulance and Crane

v) Training of Incident Management staff

vi) Documentation of Accidents and Incidents

vii) In addition to above, presence and functioning of Automatic Incident Detection System along the highway shall also be considered as one of the parameters, wherever provided.

10.3 Measurement Method

Above parameters shall be evaluated using the past one-year documentation (or available data in case of less than one-year documentation) related to Incident Management System. It may be noted that, rating of Incident Management System shall be carried out based on review of documentation and reports in past one year.

Currently, at number of projects, above information may not be readily available, for this purpose, it is necessary to implement uniformity of documentation across various projects.

10.4 Rating System

Individual parameters of Incident Management System shall be rated as given below **(Table 64)**:

Table 64 Rating System for Assessment of Incident Management System

Parameter	Criteria	Rating
Functionality of VTS	95% of the times VTS has been functional in past 1 year (i.e. at least 347 days in a year)	10
	90% to 95% of the duration VTS has been functional in past 1 year (i.e. between 328 to 346 days)	5
	Less than 90% of the duration VTS has been functional in past 1 year (i.e. less than 328 days in a year)	0
Past 1-year Patrolling distance (cumulative distance of all RPV's) (VTS reports)	More than 2000 times the project distance travelled by the Route Patrolling Van along the Project Stretch	10
	Between 1500 to 2000 times the project distance travelled by the Route Patrolling Van along the Project Stretch	5
	Less than 1500 times the project distance travelled by the Route Patrolling Van along the Project Stretch	0
Past 1-year Incident Response Time	>98% of incidents responded within 30 minutes	10
	75% to 98% of incidents responded within 30 minutes	7.5
	Less than 75% of incidents responded within 30 minutes	0
Inventory Check of RPV, Ambulance and crane	1 instance when major equipment was unavailable/non-functional in past one year	10
	2 to 3 instances when major equipment was unavailable/non-functional in past one year	5
	More than 3 instances when major equipment was unavailable/ non-functional in past one year	0
Training of Incident Management staff	Whether at least 2 numbers of 1-day Training of Incident Management staff has been conducted covering emergency medical procedure,	10
	Whether at least 1 number of 1-day Training of Incident Management staff has been conducted covering emergency medical procedure,	5
	No Training	0
Documentation of Accidents and Incidents	All the major accidents and incidents were documented in standard forms	10
	Details in 5% of reported major accidents and incidents are not properly documented	5
	More than 5% of reported major accidents and incidents are not properly documented	0
Functioning of Automatic Incident Management System in past one-year	System downtime, less than 1% of duration	10
	System downtime, between 1 to 5% of duration	5
	System downtime, more than 5% of duration	0

10.5 Overall Emergency Response System Rating

The overall rating for emergency response system shall be estimated by taking average of all ratings of different parameters considered under emergency response system.

SECTION 11

ASSET RATING OF WORK ZONE SAFETY – OPERATIONS

11.1 Introduction

Documentation of safety arrangements at work zones and review of safety arrangements during a random visit can indicate the level of safety at the work zones.

11.2 Parameters

Parameters to be considered for the rating of Work Zone Safety are:

i) Documentation of safety arrangements at work zones
ii) Review of Safety arrangement during a random visit
iii) Validation of documentation based on outcomes of surprise visit
iv) Usage of Inovative Technologies

11.3 Measurement Method

The measurement method for each of the parameter considered is as follows;

i) Documentation of safety arrangements at work zones: Past one-year documentation shall be reviewed
ii) Review of Safety arrangement during random visit: Randomly selected, at-least 3 work zones shall be reviewed by the rating agency as part of surprise visit. Video backup capturing work zone arrangement shall be maintained.

11.4 Rating System

Individual parameters of Work Zone Safety shall be rated as given below **(Table 65)**:

Table 65 Rating System for Assessment of Work Zone Safety

Parameters	Criteria and Rating
Documentation of Safety Arrangement at work zones	Documentation related to work zones in past one-year is maintained in soft copy format containing photos of safety arrangement, PPEs, incidents at work zones **– 10 points** If not maintained **- 0 points**
Review of Safety arrangement during random visit	Sign boards and Safety Furniture availability-installation arrangement as per IRC:SP:55; 100% implementation of Personal Protective Equipment at randomly selected 5 work zones which shall be reviewed in surprise visit along with video backup: • At all the 5 work zones **– 10 Points** • At 3 work zones out of 5 work zones **– 5 Points** • At 2 or less work zones out of 5 work zones **– 0 points**

Parameters	Criteria and Rating
Validation of documentation based on outcomes of surprise visit	Review of documentation of ongoing randomly selected 5 work zones during surprise visit: • Documentation in-line with past documentation submitted – **10 points** • No documentation – **0 points**
Usage of innovative technologies	• During random site visit, if innovative technologies are being employed to improve safety measures, 10 points shall be awarded. If any such innovative measures are not employed 0 points shall be awarded

11.5 Overall Work Zone Safety Rating

Overall rating for work zone safety shall be estimated by taking weighted average of all the different parameters considered under work zone safety by taking the following weights for each parameter and the weights for each parameter are given in following **Table 66**.

Table 66 Weightages of Different Parameters for Work Zone Safety Rating

Parameter	Weightage
Documentation of Safety Arrangement at work zones	20
Review of Safety arrangement during random visit	30
Validation of documentation based on outcomes of surprise visit	30
Usage of innovative technologies	20

SECTION 12

ASSET RATING OF ENCROACHMENT – OPERATIONS

12.1 Introduction

Encroachments are illegal developments/objects of any form in the Right of way of the Highway. These may put the user's safety at jeopardy.

12.2 Parameters

Parameters to be considered for assessing encroachment management along the highway are:

i) Documentation of action against encroachments.

ii) Validation of documented encroachment during surprise site visit.

12.3 Measurement Method

The measurement method for each of the parameter considered is as follows;

i) **Documentation of action against encroachments:** Past one-year documentation related to action taken with before-after photos, notices given, First Information Reports submitted to enforcement agencies against various types of encroachments shall be reviewed.

ii) **Validation of documented encroachment during surprise site visit:** Surprise Validation of documented temporary and permanent encroachments during surprise visit along with GPS coordinates and video back-up.

12.4 Rating System

Individual parameters of Encroachment Management shall be rated as given below **(Table 67)**:

Table 67 Rating System for Assessment of Encroachment Management

Parameters	Criteria and Rating
Documentation of action against Encroachments	Past one-year documentation related to action taken with before-after photos, notices given, First Information Reports submitted to enforcement agencies, follow-up with enforcement agencies against various types of encroachments has been maintained – **10 points**
Validation of documented Temporary Encroachments during surprise Site Visit	Surprise Validation of documented existing temporary encroachment along with video backup - • List is 95% validated on ground – **10 points** • Between 85% to 95% of list is validated – **5 points** • Less than 85% of list is validated – **0 points**

Parameters	Criteria and Rating
Validation of documented Permanent Encroachments during surprise site visit	Surprise Validation of documented existing permanent encroachment along with video backup - • List is completely validated on ground – **10 points** • One or more than one of the permanent encroachments is not matching with the documented list – **0 points**

12.5 Overall Encroachment Management Rating

The overall rating for encroachment management shall be estimated by taking weighted average of all the different parameters considered under encroachment management plan by taking the following weights for each parameter and the weights for each parameter are given in **Table 68**.

Table 68 Weightages of Different Assets under Encroachment Management

Parameter	Weightage
Documentation of action against encroachments	20
Validation of documented Temporary Encroachments during surprise Site Visit	40
Validation of documented Permanent Encroachments during surprise Site Visit	40

SECTION 13

ASSET RATING OF OVERALL CLEANLINESS – OPERATIONS

13.1 Introduction

For the Smooth Functioning of Highways Overall Cleanliness plays a vital role and various factors needs to be evaluated.

13.2 Parameters

The road can be divided mainly into three parts keeping in view the point of cleanliness:

i) Usage of Mechanical Equipment

ii) Project Cleanliness

- a) ROW
  - i) Median
  - ii) Kerb Side
  - iii) Shoulder
  - iv) Embankment
- b) Toll Plaza
  - i) Condition of Plaza Building
  - ii) Toll Booths Furniture
- c) Project Facilities
  - i) Bus Bay
  - ii) Truck Lay-By
  - iii) Toilet Block
  - iv) Highway Mini Nest
  - v) Rest Area

iii) Innovative Technologies

From the view of above points the asset can be evaluated on the basis of the below rating points.

13.3 Usage of Mechanical Equipments

- If mechanical equipments are deployed for cleaning of the project (with lesser manpower); 10 points shall be awarded.
- In case most of the cleaning process through manual means, 0 points shall be awarded.

13.4 Project Cleanliness

13.4.1 *ROW*

i) **Median** – From the visual aspect it is one the most important factor which subincludes the plantation done in the median, and its further maintenance and cleaning which can be evaluated on the basis of **3 points**.

ii) **Kerb Side** – Most of the dust particles are accumulated at the Kerb Side and thus its cleaning frequency should be more often and can be evaluated on **2 points**.

iii) **Shoulder** – The Unpaved shoulder is generally the most approachable area for the waste material to be dumped and hence should be properly cleaned and can be evaluated on the basis of **3 points**.

iv) **Embankment** – The Embankment generally has unwanted vegetation growth which needs to be cleaned and can be evaluated on the basis of **2 points**.

13.4.2 *Toll Plaza*

i) Condition of Plaza Building- Toll Plaza area and its surrounding needs to be cleaned on a daily basis and can be evaluated on the basis of **5 points**.

ii) Toll Booth Furniture – Toll Booth Furniture's installed inside the booths and adjoining equipment installed nearby the booth area for functioning of Toll Road can be evaluated on the basis of **5 points**.

13.4.3 *Project Facilities*

i) **Bus Bay** – The overall cleaning of the area can be evaluated on the basis of **2 points**.

ii) **Truck Lay Bye** – The overall cleaning of the area can be evaluated on the basis of **2 points**.

iii) **Toilet Block** - The availability of tools and materials required for cleaning and the overall hygiene maintained in the area can be evaluated on the basis of **3 points**.

iv) **Highway Nest Mini** – The overall structure cleaning can be evaluated on the basis of **2 points**.

v) **Rest Area** – The Maintenance upkeep of the facility, the cleaning methodology adopted can be evaluated on the basis of **1 Point**.

13.5 Innovative Technologies

- If innovative technologies are being implemented for cleaning of the project, 10 points shall be awarded
- In case project cleaning is being carried out without any innovative technologies, 0 points shall be awarded.

13.6 Overall Cleanliness Rating

The overall rating for overall cleanliness shall be estimated by taking weighted average of all the different parameters considered under overall cleanliness by taking the following weights for each parameter and the weights for each parameter are given in **Table 69**.

Table 69 Weightages for Different Parameters under Overall Cleanliness

Asset	Weightage
Usage of Mechanical Equipment	40
Project Cleanliness (average of ROW, Median and Project Facilities)	40
Usage of Innovative Technologies	20

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the Code/Guidelines/Manual, etc. from the date specified therein)

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